imeform Assessment Team

THE BIOLOGIC AND ECONOMIC ASSESSMENT OF CHLORDIMEFORM

A report of the chlordimeform assessment team to the Special Review of chlordimeform

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CHAPTER III

PREFACE

This report has been prepared to provide up-to-date information on the benefits derived from the registered use of chlordimeform and chlordimeform hydrochloride on cotton. In addition, the likelihood and degree of exposure of applicators, mixers, loaders and others involved in application procedures to chlordimeform were considered. The report is intended for use along with other available information in a risk/benefit assessment being conducted by EPA as part of a special review of chlordimeform registrations.

This report was prepared by a team of scientists from several landgrant universities and various agencies of the U.S. Department of Agriculture.

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CHAPTER V

Executive Summary

Chlordimeform is registered under the Federal Insecticide, Fungicide, and Rodenticide Act and used on cotton for the control of <u>Heliothis</u> (bollworm/tobacco budworm) and for yield enhancement. It is an important part of the pest management programs used in the production of cotton. EPA is reevaluating chlordimeform and a Notice of Special Review will likely be issued in the near future. The review is based upon EPA's determination that chlordimeform and chlordimeform HCL are possible human carcinogens based on observations of apparently dose-related increases of malignant tumors in mice.

Since the conclusion of this review could result in the cancellation of chlordimeform registraton, a team of experts was assembled to assess the need for and benefits derived from the use of chlordimeform. The team consisted of scientists from several landgrant universities and from various USDA agencies. These were researchers and extension specialists knowledgeable and experienced in cotton pest management and economics of control.

In its Special Review, EPA will perform a risk/benefit analysis. The chlordimeform assessment team has studied EPA's position and prepared an extensive report on chlordimeform use, its benefits and the economic impact. Team members consulted with many other knowledgeable people in all of the cotton growing states and assembled extensive information. Requested information included the extent and purpose of chlordimeform use and alternative means of pest control. Economic data were assembled and analyzed.

The chemical is used as a yield enhancer on early season cotton, as an ovicide and as a synergistic additive for pyrethroid treatments against bollworm/budworm. Cotton is subject to attack by over 100 arthropod pest species and many of these can result in severe economic loss. Throughout the cotton belt, the bollworm complex (bollworm/tobacco budworm) on which chlordimeform is a major management tool is considered to be the worst pest of cotton.

Chlordimeform is recommended and used on cotton in all cotton growing states as an aerial or ground application at rates of 0.125-0.25 lb/ai/A. When applied by ground equipment, the application is often a 10 to 20 inch band over the row which reduces the amount applied per acre.

The cotton acreage harvested annually in the U.S. averages 10.6 million acres (1981-1984). Approximately 28% is treated with chlordimeform. There are an estimated 11.7 million acre treatments annually on cotton and chlordimeform usage is increasing.

Chemical control of pests on cotton is imperative and chlordimeform is the only formamidine ovicide registered for use on cotton. The chemical has no adequate substitute, is an effective ovicide and yield enhancement agent, and exhibits several desirable mitigating effects on pest populations. Chlordimeform synergizes pyrethroids and certain chemical alternatives used against bollworm/budworm populations. This reduces the volume of pesticides used through lower rates and less frequent application. Chlordimeform is ideally suited for use in IPM programs due to its minimal toxicity to beneficial and nontarget organisms and its effectiveness in suppressing secondary cotton pests.

Proper use of chlordimeform has contributed to the delay of resistance to alternative insecticides. Chlordimeform is not as phytotoxic as suggested alternatives and is less toxic to beneficial arthropods including honeybees. Chlordimeform exhibits much longer effectiveness as an ovicide than suggested alternatives such as methomyl or thiodicarb.

Beneficial physiological effects on the cotton plant are indicated. Research has shown that multiple applications of chlordimeform during the squaring stage of cotton development can increase yields and result in earlier crop maturity.

Chlordimeform is restricted for use by certified applicators only. Applicators and support personnel are required to wear protective clothing and respiratory equipment, and use a closed system in transporting, mixing and transferring chlordimeform. Treated fields may not be entered for 24 hours following application. Although a few cases of exposure to chlordimeform sufficient to induce toxic symptoms have occurred, none have been observed since the above requirements were implemented.

Loss of chlordimeform would reduce average cotton yields by 2.3% and increase costs by $4.19 per acre. However, without chlordimeform as a tank-mix, resistance to pyrethroids would increase more rapidly and yields could decrease by as much as 13.1% and costs could increase by $13 per acre. The economic loss resulting from loss of chlordimeform would be approximately $156 million. The economic benefit of chlordimeform could be considerably greater than $156 million if its role in forestalling the development of resistance to pyrethroids was considered.

Based upon review and evaluation of the information assembled and included in the report and many years of field experience involving research in cotton pest control, the chlordimeform assessment team strongly recommends that registration of chlordimeform be continued.

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CHAPTER VI

INTRODUCTION

Purpose and Scope of the Report

The purpose of this report is to evaluate the biological, exposure and economic information relative to the benefits and use of chlordimeform and chlordimeform hydrochloride.

The Office of Pesticide Programs of the U.S. Environmental Protection Agency (EPA) has indicated that it will issue a Notice of Special Review of pesticide products containing chlordimeform and/or chlordimeform hydrochloride. These products are manufactured by Ciba-Geigy Corporation and NOR-AM Chemical Company and marketed under the trade names GALECRON and FUNDAL respectively. A Special Review is the process by which EPA initiates review of pesticide products, leading to an ultimate determination of whether their use or uses pose unreasonable adverse effects to humans or the environment. It replaces the previous review protocol (40 CFR 162.11) that governed "Rebuttable Presumption Against Registration" (RPAR).

The National Agricultural Pesticide Impact Assessment Program (NAPIAP) has established a review group to evaluate the impact of the proposed action on agriculture and furnish advice and information to EPA.

EPA had previously alerted the manufacturer and public in a pre-Special Review status report that EPA would issue a combined Position Document 1/2/3. By simultaneously publishing Notices of Special Review and Preliminary Determination, EPA has chosen to use the legal provision (40 CFR 154.34) allowing an expedited action toward possible cancellation, suspension, or denial of use, without undertaking the segmented procedures of a Special Review.

Brief History of Product and Use Trends

Chlordimeform was first registered for use on apples following the establishment of a residue tolerance by the Food and Drug Aministration in 1968. Additional tolerances and registrations for certain fruits and vegetables were issued shortly thereafter. Cotton received a residue tolerance and registration in 1972. Use on cotton as an ovicide for control of the bollworm and the tobacco budworm proved to be the preferred use of chlordimeform.

Because of the rather specific ovicidal activity of chlordimeform, it was readily accepted by growers and credited with unique advantages because of its narrow spectrum of insecticidal activity and other effects on insect behavior. Beneficial insects are less severely affected than with alternative insecticides making chlordimeform especially

suited for IPM programs.

Initial residue tolerances and registrations were accomplished under toxicological requirements existing at the time, which required rat and dog studies. In 1975, EPA issued new guidelines requiring oncogenicity studies on mice, and it was then reported by the National Cancer Institute that one of chlordimeform's two metabolites might be oncogenic in mice. Subsequent studies performed by Ciba-Geigy substantiated that chlordimeform could cause tumors in mice fed continuous high daily doses of chlordimeform. Consequently, Ciba-Geigy and NOR-AM voluntarily (and without EPA intervention) withdrew the product from market in 1976.

Following the completion of lengthy mouse and worker exposure studies and its submission to EPA in 1978, Ciba-Geigy requested that EPA allow chlordimeform to be marketed for use on cotton under defined conditions and label revisions. The request was approved by EPA with the following label restrictions:

1. Restricted use pesticide statement requiring applicator certification.

2. Special precaution to prevent exposure and use of protective clothing.

3. Personal precaution statement and good hygiene practice.

4. Special equipment to transport, transfer, mix the product, and closed systems.

5. Storage instructions elaborated.

Additional toxicological and exposure data were developed between 1978 and 1981 and submitted to EPA.

CHAPTER VII

CHLORDIMEFORM

A. Physical and Chemical Properties

Chlordimeform, N' -(4-chloro-o-tolyl)-N,N-dimethylformamidine and chlordimeform hydrochloride, N'-(4-chloro-o-tolyl)-N,N-dimethylformamidine monohydrochloride, belong to a class of pesticides called the formamidines. Chlordimeform is a colorless crystal and chlordimeform hydrochloride appears as white crystals in the technical state. They have a vapor pressure of 3.5×10^{4} mm Hg at 20° C, and a volatility of 4 mg/m (3) in saturated air at 20°C. They have a solubility of 0.025% in water and <20% in methanol, acetone, ethyl acetate, chloroform, benzene and hexane.

B. Trade Names and Manufacturers

Chlordimeform and chlordimeform hydrochloride, hereafter collectively referred to as chlordimeform is manufactured and marketed by NOR-AM Chemical Company as FUNDAL and by Ciba-Geigy Corporation as GALECRON.

C. Formulations Available

Chlordimeform is marketed as a 4 lb/gal emulsifiable concentrate and as a 97% soluble powder FUNDAL or 95% soluble powder GALECRON. Soluble powder formulations are packaged in water soluble packets to reduce user exposure.

D. Principal Uses - Cotton

Extensive testing has shown chlordimeform to be an effective broad spectrum miticide, ovicide and insecticide. Its principal strengths are in its ovicidal activity on lepidopterous pests and as an acaricide. Since its reintroduction into the market in 1978, chlordimeform has been used only in cotton and there principally for control of lepidopterous pests, especially the bollworm and tobacco budworm. It has recently been shown that it is also highly effective as an ovicide against fall and beet armyworm (*Spodoptera* spp.). Chlordimeform has become the standard for use as an ovicide because of its action not only as a contact material but because of its vapor activity and the residual ovicidal activity that it provides.

CHAPTER VIII

A. Survey Methods

The chlordimeform assessment team obtained estimates of

current insect control practices across the cotton belt and determined the biological and economic effects resulting from the withdrawal of chlordimeform. The team relied heavily on experts to provide estimates because of a lack of current insecticide use and pest loss data. There is some uncertainty attached to subjective estimates. However, previous experience has shown that if expert opinions are collected in a systematic way, these estimates generally approximate current or historical estimates (USDA 1981).

U.S. cotton production areas were divided into 37 subregions (Figure VIII A(1) and Table VIII A(1)). Team members selected and surveyed cotton experts in each of the subregions. Detailed information on target pests or pest complexes affecting cotton production was collected. Economically significant pests were listed in chronological order of occurrence during the growing season. For each target pest, experts estimated the percent of harvested acreage treated and listed current pesticide materials or nonchemical control practices. The percent use, dosage per acre, average number of applications per acre, and percent of treatments applied aerially were estimated for each pesticide material or practice.

The following assumptions applied to the collection of expert estimates:

(1) Current insect control practices represent an average over the past four years,

(2) Estimates represent what growers are currently doing, not what experts think growers should be doing,

(3) Cotton acreage is assumed to be an average over the past four years,

(4) Pest infestation levels are average conditions over the past four years and

(5) Pesticide use on nonharvested acreage is insignificant.

Once current insect control practices were enumerated, experts were asked to project changes in yield and control practices for three scenarios:

(1) the loss of chlordimeform alone,

(2) the loss of chlordimeform and pyrethroids and

(3) the loss of pyrethroids but not chlordimeform.

The loss of pyrethroids and chlordimeform was included

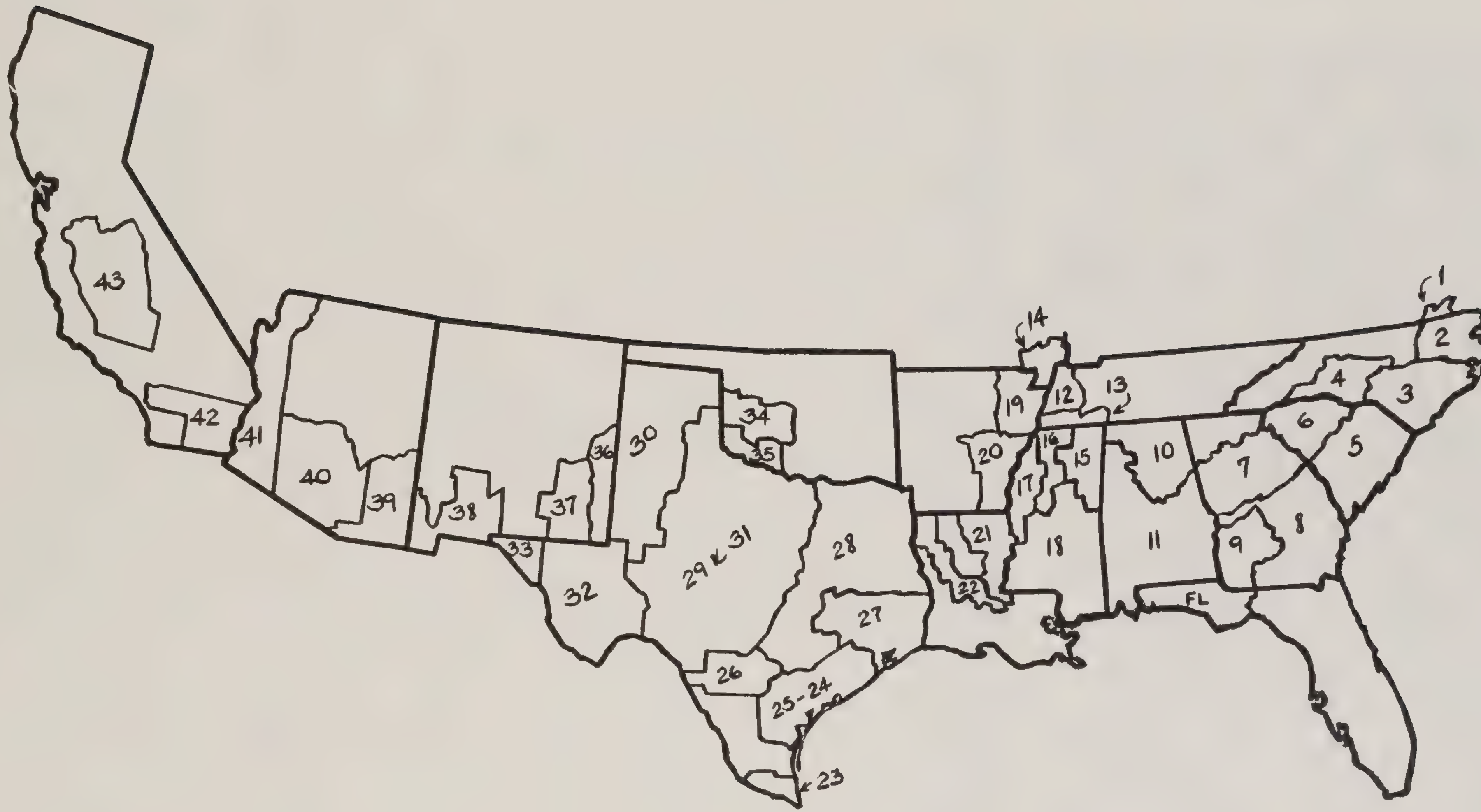

Figure VIII.A-1. Cotton production subregions

because of the risk that resistance to pyrethroids in bollworm and tobacco budworm will spread rapidly in the absence of chlordimeform. The loss of pyrethroids alone (scenario 3) can be compared with scenario 2 to show the benefits of chlordimeform in the absence of pyrethroids. Changes in yield were projected based on the proportion of current acreage treated with the chemical(s) assumed lost. Changes in insect control practices required a detailed enumeration of the shift in acreage treated and chemical substitution taking place.

Cost estimates of current insect control practices and yield and cost changes for the three scenarios were computed and returned to the experts for review and revision. Experts checked the estimates for accuracy, and in some cases, reconsidered results after comparison to other information. This last step substantiated the basis for expert opinions.

The final estimates for scouting practices are presented in Section VIII B(5), for chlordimeform uses in Section VIII C(2-6) and for economic effects in Section VIII D(3).

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followed and [illegible] quality [illegible]
presence of chlorine [illegible] form. [illegible]
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benefits of chlorine [illegible] in the [illegible]
Changes in yield were [illegible] based on [illegible]
of current storage treated with [illegible] chemical [illegible]
cost. [illegible] lowest [illegible]
detailed or [illegible] of the [illegible] treated and
chemical substitution [illegible] place.

That estimates of [illegible] control [illegible]
yield [illegible] changes [illegible]
compared and returned [illegible]
[illegible] tion. [illegible]
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VIII [illegible] and for [illegible] VIII
(3).

Table VIII A(1). Cotton Production Subregions

Number	Subregion
1,2	Virginia and North Carolina, North
3	North Carolina, South
4	North Carolina, Piedmont
5	South Carolina, Coastal Plains
6	South Carolina, Piedmont
7	Georgia, Piedmont
8,9	Georgia, East and Southwest
10 ,11	Alabama, Limestone Valley and South
FL	Florida
12	Tennessee, North Brown Loam
13	Tennessee, South Brown Loam
14	Missouri, Bootheel
15, 16, 18	Mississippi, Non Delta Area
17	Mississippi, Delta
19	Arkansas, Northeast
20	Arkansas, Southeast
21	Louisiana, Northeast
22	Louisiana, Red River Valley
23	Texas, Lower Rio Grande
24,25	Texas, Lower and Upper Coast
26	Texas, Winter Garden
27	Texas, Central River Bottom
28	Texas, Badlands
29,31	Texas, Rolling Plains and Upper Concho
30	Texas, High Plains
32	Texas, Trans Pecos
33	Texas, El Paso and Hudspeth Co.
34	Oklahoma, North
35	Oklahoma, South
36	New Mexico, Southern Plains
37	New Mexico, Pecos Valley
38	New Mexico, Upper Rio Grande
39	Arizona, Southeast
40	Arizona, Central
41	Arizona, Yuma and Mohave Co.
42	California, Lower Desert Valleys
43	California, San Joaquin Valley

B. COMMODITY INFORMATION

1. Harvested acreage and geographical distribution of of cotton in the U.S. have varied considerably during the past 20 years. This has resulted largely from

year to year price fluctuations caused by variable demands and surplus stocks of cotton. Governmental support programs have provided some stability in cotton production acreage, and with the passage of the 1986 Farm Bill, such support likely to continue.

There have been some shifts over the years in the locations that have increased or decreased in cotton production acreage. These have been marked by the advent of alternative crops that appeared to be more profitable. In many cases, areas have drastically reduced acreage as a result of insect pest pressures, the inability to control them and/or the prohibitive costs of control. Other areas have increased their acreage because cotton provided a greater profit potential than any of the other row crops. For example, the reduction of acreage during the 1970's in the southeastern U.S. resulted largely from prohibitive costs of insect control. With the introduction of the pyrethroids, reintroduction of chlordimeform, the elimination of the boll weevil as an economic pest in some regions of the southeast and lower prices received for alternative row crops, cotton acreage has expanded. Harvested acreage of cotton in the western area of the cotton belt has declined in recent years. This resulted largely from low price of cotton, government control programs, pest control costs, and high cost of irrigation. Simpson and Parvin (1983) evaluated several different cotton insect control strategies in Mississippi and concluded that as cost of pest control diminished, the value of the crop increased resulting in an increase in acreage of cotton.

Table VIII B(1) shows the average harvested acreage of cotton in the United States (by state) from 1981-1984.

2. Production and Value

The average value of the cotton crop over the last 5 years is estimated to be 3.875 billion dollars (Table VIII B(1)). Production has varied significantly according to acreage planted. Value in terms of dollars to producers also varies widely according to production and fluctuating prices.

The value of cotton goes far beyond the dollars that the producer receives. That unseen and perhaps uncalculable value lies in the economy of the regions where cotton is produced. The dollars that producers receive for cotton multiplies many times in the economy of the area. The full impact of cotton in a rural cotton community may not lend itself to being measured; nonetheless, it is real.

[illegible] ... [illegible] cotton production measures, [illegible] with the [illegible] of the 1985 farm bill, such support [illegible].

There have been some shifts [illegible] the next [illegible] occasions that [illegible] production acreage. [illegible] advent of alternative crops [illegible] profitable. In many cases, [illegible] reduced acreage, [illegible] pressures, [illegible] probably have [illegible] increased their [illegible] gains, probably [illegible] crops, for example, the [illegible] the 1970's in the [illegible] from production [illegible] introduction [illegible] [illegible] an economic [illegible] lower price [illegible] cotton, acreage has [illegible] cotton in the western [illegible] [illegible] in recent years [illegible] low price of cotton, [illegible] control costs, and high [illegible] [illegible] and [illegible] different cotton [illegible] control [illegible] Mississippi and [illegible] control [illegible] resulting in an increase in [illegible].

Table VIII B(1) shows the [illegible] of cotton in the United States [illegible] 1986.

P-duction and Value

The average value of the cotton crop over the last 5 years is estimated to [illegible] 1.5 billion dollars. (Table VIII (1)). [illegible] has varied significantly [illegible] to average [illegible] in [illegible] of dollars [illegible] also varies [illegible] according to production [illegible] prices.

[illegible] far beyond the dollars that [illegible] and [illegible] economy of the regions [illegible] dollars [illegible] prices may [illegible]

[illegible]

TABLE VIII.B-1. COTTON HARVESTED ACREAGE, LINT AND COTTONSEED PRODUCTION, AND VALUE OF PRODUCTION, 1981-84

		LINT				COTTONSEED			
STATE	HARVESTED ACREAGE (1,000 Acres)	AVERAGE YIELD/ACRE (lbs/ac.)	TOTAL PRODUCTION (1,000 bales)	PRICE (cents/lb.)	VALUE OF PRODUCTION (1,000 dol.)	TOTAL PRODUCTION (1,000 tons)	PRICE (dol./ton)	VALUE OF PRODUCTION (1,000 dol.)	TOTAL VALUE OF PRODUCTION (1,000 dol.)
AL	294.8	615.9	378.2	57.7	104,746.6	138.7	88.03	12,209.8	116,956.4
AZ	484.2	1,171.3	1,181.5	61.8	350,493.6	500.7	94.98	47,556.5	398,050.1
AK	426.2	583.5	518.2	58.3	145,005.5	202.5	87.66	17,751.2	162,756.7
CA	1,311.4	1,050.8	2,870.8	66.9	921,859.6	1,215.9	107.46	130,660.6	1,052,520.2
FL	15.3	677.3	21.5	58.9	6,083.7	8.2	82.09	673.1	6,756.8
GA	155.2	606.7	196.2	58.3	54,911.5	74.8	96.21	7,196.5	62,108.0
LA	586.3	654.4	799.2	56.8	217,904.4	307.4	84.22	25,889.2	243,793.6
MS	974.3	723.6	1,468.6	58.8	414,493.0	572.7	86.23	49,383.9	463,876.9
MO	147.3	515.0	158.0	59.0	44,741.9	65.6	81.82	5,367.4	50,109.3
NM	72.5	609.1	92.0	67.3	29,720.7	47.7	99.41	4,741.9	34,462.6
NC	76.8	563.3	90.1	61.8	26,718.5	43.4	89.61	3,889.1	30,607.6
OK	442.0	271.1	249.6	46.8	56,070.9	116.4	92.40	10,755.4	66,826.3
SC	95.7	674.3	134.5	60.7	39,179.4	53.2	90.32	4,805.0	43,984.4
TN	275.0	498.4	285.6	57.4	78,675.2	116.8	88.48	10,334.5	89,009.7
TX	4,948.7	350.2	3,610.5	51.4	890,787.0	1,684.3	96.21	162,046.5	1,052,833.5
VA	0.5	504.0	0.5	63.8	160.8	0.4	94.96	38.0	198.8
U.S.	10,306.0	561.5	12,055.0	58.4	3,381,552.3	5,148.7	95.81	493,298.6	3,874,850.9

Metcalf, Flint and Metcalf (1967) (Destructive and Useful Insects) in referring to the impact of the boll weevil to the cotton industry says, "It should not be supposed that the cotton farmer sustains all the loss. On the contrary, it is borne chiefly by the users of cotton goods." This indicates that all consumers will be impacted by the "health" of the cotton industry.

3. Major Insect Pests

Cotton is subject to attack by more than 100 arthropod pests. Their attack may come during the early stages which limits growth and fruiting and delays in production. Outbreaks during much of the fruiting cycle may severely limit production, while very late season outbreaks may cause reduction in lint quality and/or value. The following is a list of arthropod pests of cotton. A brief description of their biology and damage may be found in Appendix A.

Common Cotton Insect Pests*

Beet Armyworm
Boll Weevil
Bollworm
Cabbage Looper
Cotton Aphid
Cotton Fleahopper
Cotton Leafperforator
Cotton Leafworm
Cutworms
Darkling Ground Beetles
European Corn Borer
Fall Armyworm
Garden Webworm
Grasshoppers
Lygus Bugs
Pink Bollworm
Saltmarsh Caterpillar
Spider Mites
Stink Bugs
Soybean Looper
Thrips
Tobacco Budworm
Western Flower Thrips
Whiteflies
Whitefringed Beetle
Wireworms
Yellowstriped Armyworm

* Taken from Annual Conference Report on Cotton-Insect Research and Control: Beltwide Cotton Production Research Conference. (USDA, ARS 1985).

Metcalf. Flint and Metcalf (1962) [illegible] [illegible] (1962) in referring to the import of [illegible] soil [illegible] to the cotton industry says: "It should not be supposed that the cotton [illegible] bears all the loss. On the contrary, it is borne chiefly by the users of cotton goods." This indicates that all consumers will be impacted by the "health" of cotton insects.

Major Insect Pests

Cotton is subject to attack by more than 100 insect pests. Their attack may occur [illegible] at early stages which [illegible] growth and [illegible] delays in production. [illegible] fruiting cycle may severely [illegible] production, while very late season outbreaks may [illegible] reduce yield and quality and/or [illegible] value. The following [illegible] of the major pests of cotton. [illegible] details on their biology and damage may be found [illegible].

Common Cotton Insect Pests*

Beet Armyworm
Boll Weevil
Cabbage Looper
Cotton Aphid
Cotton Fleahopper
Cotton Leafperforator
Cotton Leafworm
Cutworms
[illegible] Ground Beetles
European Corn Borer
Fall Armyworm
Garden Webworm
Grasshoppers
Lygus Bugs
Pink Bollworm
Saltmarsh Caterpillar
Spider Mites
Stink Bugs
Soybean Looper
Thrips

Table VIII B(2). Average estimated percent reduction in cotton yields by state resulting from insect damage. 1981-1985.

Loss attributable to:	State																
	AL	AZ	AR	CA	FL	GA	LA	MS	MO	NM	NC	OK	SC	TN	TX	VA	AVG
Boll weevil	5.50	0.63	1.97	0.00	6.51	4.20	3.93	2.27	0.00	0.00	1.60	2.11	3.62	0.94	1.64	0.00	1.51
Bollworm-budworm	3.48	1.22	1.80	0.41	5.82	3.36	3.78	1.78	1.90	4.90	9.12	7.20	4.74	3.00	3.60	6.80	2.39
Cotton fleahopper	0.00	0.04	0.23	0.00	0.00	0.16	0.33	0.21	0.06	3.00	0.00	0.90	0.02	0.22	1.02	0.00	0.39
Plant bugs (Lygus)	0.84	1.22	0.99	1.07	0.14	1.26	0.40	1.28	1.92	4.40	0.30	0.00	0.52	2.76	0.31	0.00	0.86
Cotton leaf perfor.	NA	0.25	NA	0.00	NA	NA	NA	NA	NA	0.08	NA	0.00	NA	NA	0.00	NA	0.03
Pink bollworm	NA	3.16	NA	0.30	NA	NA	NA	NA	NA	2.00	NA	0.00	NA	NA	0.09	NA	0.40
Spider mites	0.63	0.22	0.12	2.15	0.11	0.17	0.40	0.28	0.16	0.60	0.10	0.27	0.34	0.75	0.31	1.00	0.71
Thrips	0.47	0.00	0.50	0.65	0.53	0.14	0.37	0.20	0.81	2.52	0.42	0.27	0.96	0.55	0.63	0.70	0.50
Others	0.79	0.75	0.00	0.04	0.90	0.48	0.51	0.55	0.58	0.66	4.94	0.30	1.47	0.98	0.62	0.00	0.52
Avg. total % loss	11.64	7.44	5.78	4.56	14.02	9.78	9.91	6.62	5.46	18.15	16.38	11.05	11.66	9.00	8.31	8.54	7.32

* Data for these tables from Proceedings of the Beltwide Cotton Production Research Conferences. 1982-1986.

** Other insects include: Fall armyworm, Beet armyworm, Stink bugs, European corn borer, Yellowstriped armyworm, Grasshoppers, Cotton aphid, Cutworms, Whitefly, and Western flower thrips.

TABLE 3. CURRENT SCOUTING PRACTICES

TECHSIM REGION	DELPHI NO.	SUBREGION	HARVESTED ACREAGE (1981-84)	PERCENT OF HARVESTED ACREAGE UNDER PRACTICE					PCT. OF TOTAL ACREAGE SCOUTED	WEIGHTED COST OF SCOUTING/ACRE
				EXTENSION	PEST CONSULTANT	PESTICIDE DEALER	HIRED SCOUTS	FARMER		
APPALACHIA	1 & 2	VIRGINIA and NORTH CAROLINA, North	47583	0.06	0.50	0.04	0.22	0.18	1.00	5.30
	3	NORTH CAROLINA, South	25710	0.06	0.50	0.04	0.22	0.18	1.00	5.30
	4	NORTH CAROLINA, Piedmont	3959	0.06	0.50	0.04	0.22	0.18	1.00	5.30
	12	TENNESSEE, North Br. Loam	207444	0.10	0.05	0.10	0.00	0.08	0.33	0.72
	13	TENNESSEE, South Br. Loam	67556	0.10	0.05	0.10	0.00	0.08	0.33	0.72
		REGIONAL ESTIMATES:	352251	0.09	0.15	0.09	0.05	0.10	0.47	1.72
SOUTHEAST	5	SOUTH CAROLINA, Coastal Plains	88023	0.10	0.35	0.05	0.30	0.20	1.00	4.22
	6	SOUTH CAROLINA, Piedmont	7703	0.10	0.35	0.05	0.30	0.20	1.00	4.22
	7	GEORGIA, Piedmont	8993	0.36	0.00	0.04	0.03	0.44	0.87	2.18
	8 & 9	GEORGIA, East and Southwest	146247	0.29	0.08	0.05	0.23	0.26	0.91	3.44
	10 & 11	ALABAMA, Limestone Valley and South	294750	0.19	0.27	0.01	0.19	0.34	1.00	2.75
	FL	FLORIDA	15250	0.29	0.10	0.00	0.10	0.30	0.79	3.67
		REGIONAL ESTIMATES:	560966	0.21	0.23	0.03	0.21	0.30	0.97	3.19
CORN BELT	14	MISSOURI, Bootheel	147250	0.06	0.15	0.10	0.02	0.40	0.73	2.33
		REGIONAL ESTIMATES:	147250	0.06	0.15	0.10	0.02	0.40	0.73	2.33
DELTA	15-16, & 18	MISSISSIPPI, Non Delta area	339425	0.35	0.25	0.10	0.10	0.10	0.90	2.97
	17	MISSISSIPPI, Delta	634825	0.00	0.87	0.03	0.00	0.07	0.97	4.57
	19	ARKANSAS, Northeast	189598	0.50	0.30	0.05	0.00	0.05	0.90	3.65
	20	ARKANSAS, Southeast	236633	0.50	0.30	0.05	0.00	0.05	0.90	3.65
	21	LOUISIANA, Northeast	514523	0.00	0.85	0.10	0.00	0.05	1.00	4.93
	22	LOUISIANA, Red River Valley	71728	0.00	0.85	0.10	0.00	0.05	1.00	4.93
		REGIONAL ESTIMATES:	1986732	0.17	0.64	0.07	0.02	0.06	0.95	4.21
SOUTHERN PLAINS	23	TEXAS, Lower Rio Grande	224750	0.00	0.40	0.50	0.00	0.00	1.00	2.05
	24 & 25	TEXAS, Upper and Lower Bend	201025	0.03	0.40	0.15	0.10	0.32	1.00	2.85
	26	TEXAS, Winter Garden	25900	0.00	0.85	0.15	0.00	0.00	1.00	6.80
	27	TEXAS, Central River Bottom	55300	0.03	0.85	0.07	0.00	0.05	1.00	6.20
	28	TEXAS, Blacklands	188600	0.20	0.10	0.05	0.10	0.55	1.00	3.25
	29 & 31	TEXAS, Rolling Plains and Upper Concho	1285425	0.10	0.01	0.05	0.02	0.50	0.68	1.26
	30	TEXAS, High Plains	2901950	0.01	0.15	0.09	0.00	0.65	0.90	1.76
	32	TEXAS, Trans Pecos Valley	29400	0.20	0.15	0.05	0.00	0.60	1.00	2.94
	33	TEXAS, El Paso and Hudspeth Counties	33375	0.35	0.13	0.22	0.00	0.30	1.00	1.84
	34	OKLAHOMA, North	110893	0.00	0.01	0.33	0.00	0.66	1.00	1.31
	35	OKLAHOMA, South	331113	0.02	0.04	0.19	0.01	0.75	1.00	1.69
		REGIONAL ESTIMATES:	5390731	0.04	0.14	0.11	0.01	0.57	0.87	1.81
MOUNTAIN STATES	36	NEW MEXICO, Southern Plains	20743	0.00	0.30	0.05	0.00	0.65	1.00	2.69
	37	NEW MEXICO, Pecos Valley	21350	0.00	0.35	0.05	0.00	0.60	1.00	2.78
	38	NEW MEXICO, Upper Rio Grande	30408	0.00	0.30	0.05	0.00	0.65	1.00	2.62
	39	ARIZONA, Southeast	46808	0.00	0.55	0.20	0.00	0.25	1.00	3.18
	40	ARIZONA, Central Arizona	339733	0.05	0.30	0.60	0.05	0.00	1.00	2.95
	41	ARIZONA, Yuma & Mohave Counties	97660	0.00	0.25	0.65	0.05	0.05	1.00	2.64
		REGIONAL ESTIMATES:	556702	0.03	0.31	0.50	0.04	0.11	1.00	2.88
WEST	42	CALIFORNIA, Imperial Valley	76125	0.00	0.00	0.00	1.00	0.00	1.00	25.00
	43	CALIFORNIA, San Joaquin Valley	1235225	0.00	0.45	0.30	0.10	0.05	0.90	3.68
		REGIONAL ESTIMATES:	1311350	0.00	0.42	0.28	0.15	0.05	0.91	4.92
TOTAL U.S. (1981-84)			10305982	0.07	0.28	0.14	0.04	0.35	0.89	2.81

4. Geographical Distribution

Many of the insect pests listed above are commonly found only in certain geographical locations of the U.S. cotton belt. Severity of attack may also vary between regions. Additionally, the degree of difficulty in control may vary considerably by region and subregion of the country. Some pests that may be easy to control in one region may essentially defy control in others due to resistance or tolerance to currently registered insecticides. Perhaps the most descriptive method of indicating geographical distribution and severity of attack by insect pests is the estimated losses incurred by the various insect pests. Table VIII B(2) developed by state extension and research entomologists shows the average estimate of damage due to insect pests by state. These data include crop years 1981-1985 as annually prepared and tabulated under the auspices of the Cotton Insect Research and Control Conference which is a part of the Beltwide Cotton Production Research Conferences and published in the proceedings thereof. (USDA, ARS 1982 through 1985).

5. Scouting and Insect Monitoring

Scouting for presence of economic infestations on insect pests is an essential component of any cotton insect management program. The information obtained concerning pest insect(s) present, population levels, and stage(s) of plant growth are essential for proper management decisions. Routine scouting also provides producers with information concerning the efficacy of insecticides already applied. The following (Table VIII B(3) is a breakdown of the percentage of acreage that is scouted by production subregion. It is further divided by the type of scout/consultant that is monitoring the fields for insects.

6. Integrated Pest Management (IPM)

Integrated pest management (IPM), for the purpose of this report, is defined as those systems (and components of systems) which are used to manage pest insect complexes in cotton. Such IPM systems integrate all available technology to achieve the most effective, environmentally acceptable (with reference to humans and other non-target organisms) and economical crop protection and production. Examples of important IPM concepts include:

a. Use of crop pest scouting and economic thresholds (pest population treatment triggers which limit insecticide use to instances where significant damage is imminent);

[illegible] between regions [illegible] mainly [illegible] difficulty in [illegible] may [illegible] and between regions [illegible] the country [illegible] currently [illegible] [illegible] in the [illegible] due to [illegible] currently [illegible] [illegible] the [illegible] [illegible] the associated [illegible] [illegible] (2) developed [illegible] and [illegible] [illegible] The Cotton Insect [illegible] Research [illegible] 199[illegible]

5. Scouting and Pest Information

Scouting [illegible] scout [illegible] [illegible] insects [illegible] is essential [illegible] insect management program. [illegible] certain [illegible] present [illegible] management [illegible] with [illegible] is used [illegible] will [illegible] [illegible] production [illegible] further divided by the type of [illegible] is [illegible] the fields for insects.

6. Integrated Pest Management (IPM)

Integrated pest management (IPM) [illegible] [illegible] systems [illegible] [illegible] technology [illegible]

b. Conservation and preservation of beneficial arthropods which feed on insect and mite pests (through use of scouting, economic thresholds and selective insecticides when available);

c. Use of cultural practices that reduce pest threat (planting date, varietal selection, water and fertility management, and crop termination, harvest and residue destruction); and

d. Discriminant and prudent use of appropriate insecticides (with respect to length of residual control, effects on non-target organisms, effects on secondary pest populations and treatment costs).

C. Use of Chlordimeform on Cotton

1. Purpose of Use

a. For insect control, chlordimeform is labeled only as an ovicide for the control of <u>Heliothis</u> spp. on cotton. However, when used against <u>Heliothis</u> spp., it suppresses beet armyworms, cotton leafperforators, pink bollworms, spider mites, thrips and western yellowstriped armyworms (USDA 1984). Populations of fall armyworms and European cornborers are also suppressed. Chlordimeform is widely used because it has very low toxicity against predators and parasites of bollworms and tobacco budworms on cotton, thus preserving them. Chlordimeform does not induce outbreak of secondary pests and suppresses some, such as spider mites. Chlordimeform is also used as a synergist of pyrethroids when used against bollworms and tobacco budworms.

b. Yield Enhancement

When chemicals with insecticidal properties are used as test chemicals for plant growth regulation, it is often difficult to distinguish plant response to the chemical per se, from relief from insect damage. However, there is ample information which suggests that some insecticidal chemicals can have physiological effects that alter the growth and development of cotton plants (Brown et al. 1962).

Chlordimeform is an ovicide that has been extensively tested and used for growth regulation on cotton when applied at the early square stage of plant development. These treatments are applied at 0.125-0.25 lbs/ai/A, 4 or 5 times per

season at 5 to 7 day intervals beginning at or just prior to square initiation. The 0.125 lb. rate is more commonly used and the common method of application is to apply the chemicals on a 10 to 20 inch band. This reduces the cost of application and the total amount of chemical required.

Yield enhancement results have been somewhat erratic, but in most cases yield increases and earliness of harvest have been reported. However, the reasons for these benefits have not been fully explained. Research indicates early season insect control, an alteration on the physiological processes within the plant and/or both. Early season use of chlordimeform has become a standard practice across much of the cotton belt and is recommended by many private consultants and several state Extension Services.

Yield enhancement effects of chlordimeform were first observed by Lincoln and Dean (1976) and Phillips et al. (1977). They reported flowering, boll retention, crop maturity and yield above that expected from insect control alone. Cathey and Bailey (1983) also found increases in fruiting and boll retention in chlordimeform-treated plots during 4 years of testing. They concluded, however, that these effects were due primarily to protection from early season insect damage. In addition, they observed a synergistic effect when chlordimeform was used with fenvalerate. In a later study, Bailey and Cathey (1985) found that chlordimeform significantly reduced emergence of plant bug nymphs from both green bean pods and cotton plants. In a 3 year study in the northern blacklands of Texas, Schuster et al. (1985) found no increase in yield from the use of chlordimeform but an indication of increase in early fruit set and erratic control of plant bugs and fleahoppers, suggesting possible physiological effect. White and Bourland (1985) concluded that the beneficial effects of chlordimeform were not limited to insect control alone, but that the chemical had a beneficial effect by altering physiological processes. Hopkins (1985) and Benedict et al. (1985) also concluded that both a physiological and insecticidal effect resulted from chlordimeform treatments.

In laboratory, growth chamber and greenhouse studies, numerous researchers have observed both yield increases and alterations in the physiology of cotton plants treated with chlordimeform.

as 5 to 7 ... per ... [illegible]
... to ... [illegible]. ... [illegible]
were ... more ... [illegible]
... applied ... [illegible]
to 20 ... This reduce ... [illegible]
... and the total amount ... [illegible]
required.

Yield enhancement ... [illegible]
... [illegible]
... [illegible]

Yield enhancement ... [illegible]

... [illegible]

... that those ... [illegible]
... [illegible]
... [illegible]
... [illegible]
... [illegible]
... (1985) found ... [illegible]
... [illegible]
... [illegible]
... in the ... [illegible]
... et al. (1985) found no ... [illegible]
... of ... [illegible]
of increase ... [illegible]
... [illegible]
... [illegible]
... (1983) ... [illegible]
... [illegible]
... control area ... [illegible]
... [illegible]
... (1981) and ... [illegible]
also concluded that ... [illegible]
... [illegible]
... treatments.

... [illegible]

Campbell et al. (1979) reported yield increases from multiple applications of the chemical in an insect-free greenhouse environment. In an experiment conducted by Weaver (1983), chlordimeform caused a reduction of N and P concentrations in cotton leaf petioles and a significant increase in yield. These results suggest a more rapid conversion of N and P into seed protein. Weaver and Bhardwaj (1985) also reported a growth regulating effect from chlordimeform treatments that resulted in increased flower production during the second and third week of flowering. Other measured physiological responses to chlordimeform reported by Cothren et al. (1984) and Guthrie (1986) include increased carbon dioxide uptake which suggests increased photosynthesis; reduced petiole nitrate levels, suggesting enhanced nitrogen utilization and increased sugar levels, suggesting more energy available to support boll development. They also observed alterations in root, stem and leaf nutrient levels. Bauer and Cothren (1986) also found an increase in stomatal conductance, transpiration rate and apparent photosynthesis of plants treated with chlordimeform in growth chambers. One other interesting effect of this chemical was reported by Teague et al. (1986). They found an increase in fiber quality that resulted in a significantly higher lint value for the treated cotton.

Research has shown that multiple applications of chlordimeform during the squaring stage of cotton development can have a beneficial effect in the form of increased yields (yield enhancement) and earliness of harvest. A physiological effect as well as an insecticidal effect is indicated.

2. Geographical Areas of Use

Cotton is grown in seven production regions including Appalachia, Southeast, Corn Belt (Missouri Bootheel), Delta, Southern Plains, Mountain States and the West (California).

Appalachia

Cotton is grown in 6 subregions in the Appalachian region including Virginia, North Carolina and Tennessee. The average harvested acres, percentage of harvested acres treated one or more times with insecticides and current estimated expenditures for all insecticides, yield enhancement treatments and scouting costs for Appalachia are shown in Table VIII C(1)

(Current Practices). Table VIII C(2) shows the uses of chlordimeform. As shown, 24% of harvested cotton acres are treated with chlordimeform. Of these total acres, approximately 0.49 treatments (per harvested acre) are for yield enhancement and 0.22 treatments (per harvested acre) are applied for insect control It is estimated that there are 249,419 acre treatments of chlordimeform annually in the Appalachian region.

Southeast

The Southeast region includes cotton grown in 6 subregions as shown in Table VIII C(3). Current insecticide usage and other pertinent crop data are also presented in this table. Table VIII C(4) shows the usage of chlordimeform in the Southeast. As shown, 71% of the harvest cotton acres are treated with chlordimeform. Approximately 0.96 treatments (per harvested acre) are for yield enhancement and 3.00 treatments (per harvested acre) are for insect control. These estimates indicate that there are 2,223,484 acre treatments of chlordimeform annually in the Southeast Region.

Delta and Missouri Bootheel

Cotton grown in 7 subregions in the Delta Region and the Missouri Bootheel is presented in Table VIII C(5). Current insecticide usage and other pertinent crop data are also presented in this table. Table VIII C(6) shows the usage of chlordimeform in these regions. The percentage of the harvested cotton acres treated with chlordimeform is 15% for Missouri and 63% for the Delta Region. Approximately 0.39 and 0.81 treatments (per harvested acre) are for yield enhancement and 0.08 and 1.57 treatments (per harvested acre) are for insect control in Missouri and the Delta Region respectively. These estimates indicate 4,797,715 acre treatments of chlordimeform annually in the Delta Region and Missouri. Many early season treatments are applied in 10 to 20 inch bands reducing the total pounds of chlordimeform applied.

Southern Plains

The Southern Plains Region includes very diverse cotton production areas with 11 subregions in Texas and Oklahoma (Table VIII C(7) (Current Practices)). The Southern Plains area represents

[illegible] (treatments). Table III (2), [illegible]
[illegible] is shown. [illegible]
[illegible] cotton acres are [illegible]
[illegible] their [illegible]
approximately 1.43 [illegible]
a [illegible] for yield enhancement and
[illegible] (per harvested acre) [illegible]
[illegible] cont[illegible] estimated [illegible]
245,411 acres [illegible] in the
in the Rural [illegible] region.

The, sclerotic [illegible]
[illegible] as shown [illegible]
[illegible]
are [illegible] in the [illegible]
[illegible] were not used [illegible]
[illegible] A. [illegible]
[illegible] with [illegible]
Approximately [illegible] treatment [illegible]
acre) [illegible] enhancement [illegible]
[illegible] cost [illegible]
control. These [illegible]
[illegible] of [illegible]
annually in the southeast region.

Cotton grown in 7 [illegible] regions in the Delta Region
and [illegible] is presented in Table
III (5), [illegible] use [illegible] and [illegible]
pertinent [illegible] 9 [illegible]
[illegible] Table III (5) shows the [illegible]
[illegible] alone. The [illegible]
per [illegible] harvested [illegible]
[illegible] is [illegible]
region. Approximately 0.59 and [illegible]
[illegible] harvested acre [illegible]
[illegible] 0.[illegible] and 1.5 [illegible] treatments [illegible]
[illegible] insect control [illegible]
the Delta Region, respectively, [illegible]
[illegible] indicate [illegible]
[illegible] in the Delta
[illegible] acres
[illegible]
[illegible]

[illegible]

Table VIII.C-1. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, Appalachia

SUBREGION	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars): YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	TOTAL EXPENDITURES (Dollars)
VA and NC, North	47,583	98	4.764	226,685	2.71	25.80	5.30	33.81	1,608,781
NC, South	25,710	100	10.913	280,573	7.04	57.84	5.30	70.18	1,804,328
NC, Piedmont	3,958	85	4.475	17,712	1.16	25.39	5.30	31.85	126,062
TN, North Brown Loam	207,444	100	4.606	955,487	1.00	14.01	0.72	15.73	3,263,094
TN, South Brown Loam	67,556	100	4.806	324,674	1.00	14.86	0.72	16.58	1,120,078
REGIONAL ESTIMATES	352,251	100	5.125	1,805,132	1.67	19.09	1.72	22.49	7,922,344

Table VIII.C-2. Current chlordimeform use statistics, Appalachia

SUBREGION	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE: YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	CHLORDIMEFORM ACRE-TREATMENTS: TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	POUNDS OF CHLORDIMEFORM (Active ingredients): RATE PER ACRE-TREATMENT	TOTAL
VA and NC, North	20	27	0.650	0.192	0.842	40,065	34	0.190	7,612
NC, South	40	47	1.575	0.434	2.009	51,651	58	0.190	9,814
NC, Piedmont	10	13	0.300	0.048	0.348	1,377	0	0.190	262
TN, North Brown Loam	12	22	0.366	0.200	0.566	117,413	7	0.125	14,677
TN, South Brown Loam	12	22	0.366	0.210	0.576	38,912	7	0.125	4,864
REGIONAL ESTIMATES	15	24	0.492	0.216	0.708	249,419	22	0.149	37,228

Table VIII.C-3. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, Southeast

SUBREGION	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars)				TOTAL EXPENDITURES (Dollars)
					YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	
SC, Coastal Plains	88,023	99	10.990	967,373	2.35	66.05	4.22	72.62	6,392,230
SC, Piedmont	7,703	90	5.259	40,510	1.48	28.78	4.22	34.48	265,599
GA, Piedmont	8,993	95	5.909	53,140	0.97	42.85	2.18	46.00	413,678
GA, East and Southwest	146,247	100	13.485	1,972,141	4.06	88.33	3.44	95.83	14,014,850
AL, Limestone Valley and South	294,750	100	9.698	2,858,486	1.34	65.32	2.75	69.41	20,458,598
FL	15,250	100	18.360	279,990	1.83	141.38	3.67	146.88	2,239,920
REGIONAL ESTIMATES	560,966	100	11.002	6,171,639	2.22	72.64	3.20	78.05	43,784,875

Table VIII.C-4. Current chlordimeform use statistics, Southeast

SUBREGION	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE			CHLORDIMEFORM ACRE-TREATMENTS		POUNDS OF CHLORDIMEFORM (Active ingredients)	
			YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	RATE PER ACRE-TREATMENT	TOTAL
SC, Coastal Plains	15	75	0.525	2.338	2.863	252,010	48	0.158	39,870
SC, Piedmont	10	36	0.340	0.658	0.998	7,688	40	0.167	1,285
GA, Piedmont	20	50	0.465	1.530	1.995	17,941	18	0.125	2,243
GA, East and Southwest	50	70	1.938	2.925	4.863	711,199	16	0.125	88,900
AL, Limestone Valley and South	20	70	0.640	3.250	3.890	1,146,578	59	0.125	143,322
FL	25	95	0.875	4.900	5.775	88,069	50	0.125	11,009
REGIONAL ESTIMATES	27	71	0.960	3.004	3.964	2,223,484	43	0.129	286,628

Table VIII.C-5. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, Corn Belt and Delta

REGION - SUBREGION	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars) YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	TOTAL EXPENDITURES (Dollars)
CORN BELT - MO, Bootheel	147,250	100	3.922	577,515	1.14	16.31	2.33	19.78	2,912,605
DELTA - MS, Non Delta area	339,425	100	9.106	3,090,804	0.87	41.32	2.97	45.16	15,328,433
MS, Delta	634,825	100	10.591	6,723,432	1.75	57.45	4.57	63.77	40,482,790
AK, Northeast	189,598	100	4.295	814,323	4.25	15.33	3.65	23.23	4,404,362
AK, Southeast	236,633	100	9.072	2,146,735	7.29	41.46	3.65	52.40	12,399,569
LA, Northeast	514,523	100	12.155	6,254,027	2.25	65.53	4.93	72.71	37,410,967
LA, Red River Valley	71,728	100	13.710	983,391	1.69	61.87	4.93	68.49	4,912,651
REGIONAL ESTIMATES	1,986,732	100	10.073	20,012,712	2.63	51.02	4.21	57.85	114,938,772

Table VIII.C-6. Current chlordimeform use statistics, Corn Belt and Delta

REGION - SUBREGION	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE: YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	CHLORDIMEFORM ACRE-TREATMENTS: TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	POUNDS OF CHLORDIMEFORM (Active ingredients): RATE PER ACRE-TREATMENT	TOTAL
CORN BELT - MO, Bootheel	12	15	0.390	0.084	0.474	69,797	32	0.125	8,725
DELTA - MS, Non Delta area	10	52	0.310	0.840	1.150	390,339	39	0.125	48,792
MS, Delta	20	75	0.620	2.260	2.880	1,828,296	69	0.125	228,537
AK, Northeast	35	85	1.225	0.640	1.865	353,600	59	0.125	44,200
AK, Southeast	60	90	2.100	1.798	3.898	922,395	62	0.125	115,299
LA, Northeast	20	40	0.680	1.565	2.245	1,155,104	75	0.125	144,388
LA, Red River Valley	15	30	0.510	0.580	1.090	78,184	67	0.125	9,773
REGIONAL ESTIMATES	24	63	0.813	1.567	2.380	4,727,918	66	0.125	590,990

about 50% of the U.S. cotton acres. Insecticide expenditures per acre also varies widely among the subregions as shown in Table VIII C(7). The subregions, the Rolling Plains, Upper Concho and High Plains account for 78% of the cotton acres in the region. These 3 subregions have very small expenditures for insect control when compared to other areas. Therefore, the percentage of acres requiring one or more insecticide treatments is only 58%. The Lower Rio Grande, Winter Garden and Central River Bottom areas have relatively high insecticide use. Yield enhancement treatments with chlordimeform are estimated to be only 1% while 12% of the acreage is treated with chlordimeform for insect control (Table VIII C(8)). There is an estimated 1,247,002 acre treatments with chlordimeform in this region.

Mountain States and West

Cotton is grown in 8 subregions in the Mountain States and the West. These are shown in Table VIII C(9) (Current Practices). Chlordimeform is rarely used for yield enhancement in the Mountain States and the West. However, based on the estimates of VIII C(10), it is used on 68% of the acres in New Mexico and Arizona, and 100% of the acreage in the lower desert valleys of California for control of Heliothis spp. There are an estimated 2,126,341 acre treatments with chlordimeform annually in these regions.

3. Total Use of Chlordimeform on U.S. Cotton

Of the 10,305,982 harvested acres of cotton in the U.S. (1981-1984), Table VIII C(11), chlordimeform was applied to an estimated 28% of these acres for both ovicidal and yield enhancement purposes. The total acre treatments with chlordimeform on harvested U.S. cotton acres are estimated to be about 10.6 million.

4. Usage of Chlordimeform (Amounts)

The amount of chlordimeform used on cotton is estimated to be 1.5 million pounds/ai annually as shown in Table VIII C(12). Industry estimates for 1985 amount to 1.2 to 1.4 million lbs/ai. Field experts believe that chlordimeform usage is increasing because of an increased emphasis across the cotton belt on crop earliness. Because of chlordimeform's selective insecticidal activity which preserves beneficial arthropods that attack Heliothsis spp., it is used by many

Table VIII.C-7. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, Southern Plains

REGION - SUBREGION	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars)				TOTAL EXPENDITURES (Dollars)
					YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	
TX, Lower Rio Grande	224,750	100	12.610	2,834,098	0.74	72.10	2.05	74.89	16,831,528
TX, Upper and Lower Coast	201,025	97	5.721	1,150,064	1.45	25.11	2.85	29.41	5,912,145
TX, Winter Garden	25,900	100	16.850	436,415	0.00	130.51	6.80	137.31	3,556,329
TX, Central River Bottom	58,300	98	8.026	467,916	0.00	58.86	6.20	65.06	3,792,998
TX, Blacklands	188,600	92	3.124	589,186	0.00	13.70	3.25	16.95	3,196,770
TX, Rolling Plains and Upper Concho	1,285,425	15	0.424	545,020	0.00	2.53	1.26	3.79	4,871,761
TX, High Plains	2,901,950	65	1.171	3,398,183	0.00	7.75	1.76	9.51	27,597,545
TX, Trans Pecos	29,400	92	3.504	103,018	1.11	24.22	2.94	28.27	831,138
TX, El Paso and Hudspeth Counties	33,375	85	4.336	144,714	0.55	29.89	1.84	32.28	1,077,345
OK, North	110,893	45	0.437	48,460	0.00	2.63	1.31	3.94	436,918
OK, South	331,113	80	1.610	533,092	0.00	11.11	1.69	12.80	4,238,246
REGIONAL ESTIMATES	5,390,731	58	1.901	10,250,166	0.09	11.51	1.81	13.42	72,342,723

Table VIII.C-8. Current chlordimeform use statistics, Southern Plains

SUBREGION	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE			CHLORDIMEFORM ACRE-TREATMENTS		POUNDS OF CHLORDIMEFORM (Active ingredients)	
			YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	RATE PER ACRE-TREATMENT	TOTAL
TX, Lower Rio Grande	5	60	0.158	1.410	1.568	352,408	69	0.125	44,051
TX, Upper and Lower Coast	8	40	0.280	0.319	0.599	120,414	41	0.125	15,052
TX, Winter Garden	0	40	0.000	3.600	3.600	93,240	100	0.125	11,655
TX, Central River Bottom	0	20	0.000	0.588	0.588	34,280	100	0.125	4,285
TX, Blacklands	0	9	0.000	0.033	0.033	6,224	35	0.125	778
TX, Rolling Plains and Upper Concho	0	2	0.000	0.025	0.025	32,136	45	0.125	4,017
TX, High Plains	0	8	0.000	0.093	0.093	269,881	64	0.125	33,735
TX, Trans Pecos	6	45	0.226	0.925	1.151	33,839	92	0.125	4,230
TX, El Paso and Hudspeth Counties	4	25	0.136	0.450	0.586	19,558	81	0.125	2,445
OK, North	0	6	0.000	0.083	0.083	9,204	86	0.125	1,151
OK, South	0	30	0.000	0.833	0.833	275,817	94	0.125	34,477
REGIONAL ESTIMATES	1	12	0.019	0.212	0.231	1,247,002	74	0.125	155,875

Table VIII.C-9. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, Mountain States and West

REGION - SUBREGION	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars) YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	TOTAL EXPENDITURES (Dollars)
MOUNTAIN STATES -									
NM, Southern Plains	20,743	60	1.150	23,854	0.00	7.43	2.69	10.12	209,919
NM, Pecos Valley	21,350	92	4.031	86,062	0.00	22.08	2.78	24.86	530,761
NM, Upper Rio Grande	30,408	87	3.055	92,896	0.00	20.83	2.62	23.45	713,068
AZ, Southeast	46,808	95	4.330	202,679	0.00	54.21	3.18	57.39	2,686,311
AZ, Central Arizona	339,733	100	10.265	3,487,359	0.00	100.45	2.95	103.40	35,128,392
AZ, Yuma and Mohave Counties	97,660	100	15.183	1,482,772	0.00	267.97	2.64	270.61	26,427,773
REGIONAL ESTIMATES	556,702	97	9.656	5,375,622	0.00	115.13	2.88	118.01	65,696,224
WEST - CA, Lower Desert Valleys	76,125	100	14.990	1,141,114	0.00	251.96	25.00	276.96	21,083,580
CA, San Joaquin Valley	1,235,225	100	3.157	3,899,605	0.00	45.02	3.68	48.70	60,155,458
REGIONAL ESTIMATES	1,311,350	100	3.844	5,040,719	0.00	57.03	4.92	61.95	81,239,038

Table VIII.C-10. Current chlordimeform use statistics, Mountain States and West

REGION - SUBREGION	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE: YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	CHLORDIMEFORM ACRE-TREATMENTS: TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	POUNDS OF CHLORDIMEFORM (Active ingredients): RATE PER ACRE-TREATMENT	TOTAL
MOUNTAIN STATES -									
NM, Southern Plains	0	1	0.000	0.007	0.007	145	90	0.190	28
NM, Pecos Valley	0	7	0.000	0.188	0.188	4,014	82	0.190	763
NM, Upper Rio Grande	0	7	0.000	0.070	0.070	2,129	10	0.190	404
AZ, Southeast	0	45	0.000	0.610	0.610	28,553	68	0.188	5,368
AZ, Central Arizona	0	75	0.000	2.835	2.835	963,143	70	0.188	181,071
AZ, Yuma and Mohave Counties	0	100	0.000	8.800	8.800	859,408	92	0.193	165,670
REGIONAL ESTIMATES	0	68	0.000	3.336	3.336	1,857,391	80	0.190	353,304
WEST - CA, Lower Desert Valleys	0	95	0.000	3.533	3.533	268,950	97	0.232	62,354
CA, San Joaquin Valley	0	0	0.000	0.000	0.000	0	0	0.000	0
REGIONAL ESTIMATES	0	6	0.000	0.205	0.205	268,950	97	0.232	62,354

Table VIII.C-11. Harvested acreage, acreage treated, average number of treatments, acre-treatments, and insect control expenditures, All Production Regions

AREA	HARVESTED ACREAGE	HARV. ACR. TREATED WITH INSECTICIDES (Percent)	NUMBER OF TREATMENTS PER HARV. ACRE	TOTAL ACRE-TREATMENTS	CURRENT EXPENDITURES PER ACRE (Dollars)				TOTAL EXPENDITURES (Dollars)
					YIELD ENHANCEMENT	INSECT CONTROL	SCOUTING	TOTAL EXP. PER ACRE	
ALL PRODUCTION REGIONS	10,305,982	78	4.777	49,233,504	75	34.17	2.81	37.73	388,836,580

Table VIII.C-12. Current chlordimeform use statistics, All Production Regions

AREA	HARVESTED ACREAGE TREATED FOR YIELD ENHANCEMENT (Percent)	HARVESTED ACREAGE TREATED FOR ALL USES (Percent)	NUMBER OF CHLORDIMEFORM TREATMENTS PER ACRE			CHLORDIMEFORM ACRE-TREATMENTS		POUNDS OF CHLORDIMEFORM (Active ingredients)	
			YIELD ENHANCEMENT	INSECT CONTROL	TOTAL	TOTAL ACRE-TREATMENTS	AERIAL APPLICATION (Percent)	RATE PER ACRE-TREATMENT	TOTAL
ALL PRODUCTION REGIONS	7	28	0.241	0.792	1.033	10,643,960	64	0.140	1,495,104

cotton producers for early season treatments. Usage is increasing dramatically in some areas as increasing numbers of growers add chlordimeform to pyrethroid applications as a synergist in an effort to control pyrethroid resistant populations of <u>Heliothis</u> <u>virescens</u>.

5. Application Rates

a. Chlordimeform is labeled for use at 0.125-0.25 lb/A. However, the lower rate is the most widely used rate of application. The estimated average rate is 0.140 lb/A.

b. When chlordimeform is applied as a yield enhancer, it is usually applied at 7 day intervals. When applied for control of <u>Heliothis</u> spp., it is added as needed during period of peak oviposition or it may be applied at 5 to 10 day intervals depending upon the severity of the pest problem.

6. Method of Application

The method of application varies greatly between regions. Tables VIII C(2), C(4), C(6), C(8) and C(10). In the West Region, 97-100% of the acre treatments are applied by aircraft while in the Delta and Southern Plains regions 66 and 74% of the treatments are applied by aircraft respectively. When the entire cotton belt is considered, 64% of the chlordimeform treatments are applied by aircraft (Table VIII C(12)). It is estimated that 50% of yield enhancement treatments applied with ground equipment are banded applications.

D. Impact of Loss of Chlordimeform

The following sections, Alternative Control Systems and Resistance Management, present the role and significance of chlordimeform as used in various IPM systems across the cotton belt.

1. Alternative Control Systems

a. Beneficial Arthropods

Preservation and conservation of predators and parasites of arthropod pests is a widely used strategy which is helpful in managing bollworms and tobacco budworms. This strategy depends heavily on either abstaining from use of chemicals for as long as possible or choosing

chemicals and rates which do little harm to the beneficial arthropod complex in the field (Newsom et al. 1976; King 1986). Chlordimeform is unique in that it can be used to manage Heliothis spp. and other insect pests in cotton fields without destroying the beneficial arthropod complex (Dittrich 1967; Lingren and Wolfenbarger 1976; Campbell et al. 1979; Price et al. 1981; DuRant 1985; Benedict et al. 1986). In combination with low rates of pyrethroid insecticides, beneficial arthropods are reduced, but not eliminated (Reynolds and Hannibal 1979). Additionally, the effect of chlordimeform on beneficial arthropod eggs is minimal (Bull and House 1978; Benedict et al. 1986). Essentially all effective alternatives to chlordimeform are devastating to the beneficial arthropod complex (Newsom and Smith 1949; Campbell and Hutchins 1952; van den Bosch et al. 1956; Burke 1959; Leigh et al. 1966; Harding et al. 1975; Plapp and Bull 1978; Wilkinson et al. 1979). Methomyl, an effective ovicide which has been proposed as a substitute for chlordimeform is considerably more toxic to honey bees (Johansen 1972) and beneficial arthropods than is chlordimeform (Dzuik 1977; Plapp and Bull 1978; Pitts and Pieters 1982; Benedict et al. 1986) (See also Section VIII E). In early season when protection of beneficial insects is of utmost importance, chlordimeform can be used to suppress pest insect populations and/or enhance cotton yields with minimal effects on beneficial insects. The biological insecticides are the only registered, alternative insecticides which can be used on cotton in this manner without beneficial arthropod disruption. These insecticides, Bacillus thuringiensis and Heliothis Nuclear Polyhedrosis Virus, are safe to beneficial arthropods, but provide erratic control of bollworms and tobacco budworms unless applied in combination with chlordimeform (Allen 1980; Yearian and Phillips 1983). No control of other cotton insect pests such as cotton fleahopper, aphids, mites, etc. can be expected from the biological products used alone. Further discussion of effects on beneficial and nontarget arthropods is found in Section VIII E.

b. Secondary Pests

The importance of the effect of pesticides on secondary pest populations has been discussed by many authors. Often broad spectrum insecticides in the four major insecticide classes (organochlorines, organophosphates, carbamates, and pyrethroids) provide control of target

pests. However, they have little effect on secondary pests and destroy the predators and parasites which hold the secondary pest populations in check. This frequently results in a major increase of the secondary pest population (Newsom et al. 1976). Chlordimeform is a selective insecticide which often prevents secondary pest outbreaks. When used alone, chlordimeform has little effect on the beneficial arthropod complex. When compared with other insecticide standards, several researchers have demonstrated in field tests that chlordimeform alone or mixed with other products has provided suppression of cotton fleahopper, pink bollworm, spider mites, Lygus spp., cotton leafperforator, whitefly, thrips, and beet and yellowstriped armyworm (Dittrich 1966; Reynolds and Hannibal 1979; Price et al. 1981; Knowles 1982; Tuttle and Mullis 1982; Burris and Crawford 1983; Stanford 1983; Tuttle and Mullis 1983; Benedict et al. 1986, Anon. 1984; and Burris et al. 1986). In addition, Hirata and Sogawa (1976) reported that chlordimeform inhibits feeding by plant sucking insects. This finding agrees with observations from field tests in cotton (Khalid et al. 1975; Phillips et al. 1977; Cathey and Bailey 1984; Cothran et al. 1984; Weaver et al. 1985; White and Bourland 1986; and Benedict et al. 1986).

c. Ovicidal Activity and Methomyl Limitations

As previously noted, chlordimeform is a highly selective insecticide. It has a broad spectrum of effects on those insects upon which it is active. Its ovicidal activity on insects and mites is widely reported in the literature (Dittrich 1966, 1967; Wolfenbarger et al. 1979; Pitts and Pieters 1980; Knowles 1982; and Bell and Luttrell 1985). Methomyl is another insecticide which has been shown to be effective for killing Heliothis spp. eggs (Campbell et. al. 1979; Pieters and Pitts 1978; Pitts and Pieters 1982; Bell and Luttrell, 1985; and Roush, 1986). There are, however, some distinct differences between the ovicidal activities of these two compounds. Methomyl is a short residual action ovicide which kills only by directly contacting Heliothis spp. eggs (Campbell et al., 1979). Chlordimeform is a longer residual action compound which is absorbed by the plant foliage and released slowly for 96 hours. It kills Heliothis spp. eggs by both contact and vapor action, a characteristic which allows it to be effective against eggs on the top and bottom sides of cotton leaves and eggs deposited deeply

[illegible]

c. Ovicidal Activity and Behavioral Implications

As previously noted, [illegible] selective insecticide [illegible] it has a broad spectrum of [illegible] [illegible] is widely reported in the literature [illegible]

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in the plant canopy (Dittrick 1967; Phillips 1971; Campbell et al. 1979; and Salvisburg et al., 1980). As previously mentioned, methomyl is considerably more toxic to beneficial arthropods than is chlordimeform. Another major limitation to the replacement of chlordimeform with methomyl is the well known phytotoxic action of methomyl to cotton foliage (Wolfenbarger and Redfern 1968; McGarr 1973; Canerday 1975; Kinzer et al. 1976; Lincoln and Dean 1976; and DuRant 1977). Populations of Heliothis virescens in some areas have developed high levels of resistance to methomyl (Martinez-Carrillo and Reynolds 1983; and Roush and Wolfenbarger 1985). Intensified use of methomyl will only speed development of resistance in other areas. In contrast, resistance to chlordimeform has not been observed in the field and attempts to select for resistance to chlordimeform in H. virescens in the laboratory have not been successful (Crowder et al. 1984). Furthermore, chlordimeform has been shown to be only slightly less effective against the eggs of organophosphate resistant H. virescens than against the eggs of an organophosphate susceptible laboratory strain (Bull and House 1978). Chlordimeform was as effective against the eggs of pyrethroid resistant tobacco budworm as against the eggs of a susceptible laboratory strain (Bell and Luttrell 1984; and Roush 1986). These observations suggest that methomyl would soon be rendered ineffective by the development of resistance if chlordimeform were removed from the market. These observations add to evidence that chlordimeform is an essential tool for use against organophosphate and pyrethroid resistant tobacco budworms. Further discussion of resistance is included in Section VIII D(2) of this report.

Thiodicarb is a second suggested alternative to chlordimeform as an ovicide for bollworm and tobacco budworm in cotton. Research and use experience with this compound are limited and its ovicidal properties are not widely known. However, since thiodicarb is labeled as an ovicide at the same rates at which it is labeled as a larvacide (0.6-0.9 lb/ai/A) adverse effects on beneficial and nontarget arthropods should be expected. Since thiodicarb is chemically similar to methomyl, some of the limitations associated with the use of methomyl as an ovicide may be anticipated. These would certainly include its short-residual contact activity, and might also include its phytotoxic effects and potential for

Campbell et al., 1979; and [illegible] 1980). As previously [illegible], [illegible] relatively more toxic to [illegible] than is chlordimeform [illegible]. [illegible] to the replacement of chlordimeform [illegible] the well known [illegible] of [illegible] cotton foliage [illegible] 1979; [illegible] 1975 [illegible] 1977 [illegible] 1981; populations of [illegible] have [illegible] methomyl [illegible] and [illegible] use of methomyl will [illegible] resistance [illegible]. [illegible] resistance to chlordimeform [illegible] in the field [illegible] to chlordimeform in [illegible] the laboratory have [illegible] et al. 1984). [illegible] been shown to [illegible] against the [illegible] virescens [illegible] organophosphate [illegible] resistant [illegible] a susceptible laboratory strain [illegible] and Luttrell 1984; and Roush [illegible]. These [illegible] suggest that methomyl could [illegible] tend [illegible] the development of resistance to chlordimeform [illegible] chlordimeform [illegible] cotton [illegible] a further discussion of resistance is included in section VIII D(4) of this report.

[illegible] is a second suggested alternative to chlordimeform [illegible] bollworm in cotton. [illegible] with this compound [illegible] physical properties are not widely [illegible]. However, since [illegible] it is the same [illegible] at which it is [illegible] 10.6-0.9 mm [illegible]

resistance development. Finally, at the labeled rates, thiodicarb is 3 to 4 times more expensive than either chlordimeform or methomyl.

d. Chlordimeform as a Larvicide and a Synergist

When chlordimeform is applied alone it is unimpressive as a larvacide for Heliothis spp. (Price and Young 1975; Streibert and Dittrich 1977; Price et al. 1981, Luttrell et al. 1983, 1984, 1985, and 1986; Luttrell and Martin 1985; Burris et al. 1986; and Gary et al. 1986). It has a strong ability to synergize other compounds including organochlorines, organophosphates, carbamates, pyrethroids, insect growth regulators and biological insecticides (Plapp, 1976, 1979; Rajakulendran and Plapp, 1982; and Mohamed et al., 1983), whereas, the suggested replacement compound, methomyl, lacks synergistic activity against tobacco budworm (DuRant, 1984; and Roush, 1978). Luttrell and his co-workers have shown in five field experiments over 3 years that consistently excellent Heliothis spp. control and improved cotton yields can be obtained using a three way mixture of chlordimeform, methomyl and a pyrethroid each at 1/4 its lowest labelled rate (Roush 1986). This work indicates that reduced rates of these three compounds can be used to control Heliothis spp. at reduced costs. Recent modeling studies by Knipling and Klassen (1984), Curtis (1985) and Mani (1985) have shown that mixtures of dissimilar chemicals are less likely to promote resistance development than alternating between dissimilar chemicals on successive treatment dates. A more detailed discussion of chlordimeform synergism and resistance management is provided in Section VIII D(2) of this report.

e. Acute Effects on Adults and Sublethal Effects on Adults and Larvae

Chlordimeform causes only low levels of adult Heliothis spp. mortality. However, sublethal effects on moths limit their ability to lay viable eggs. Phillips (1971) and Campbell et al. (1979) reported increased mating, reduced oviposition and strongly reduced egg hatch after moths were exposed to chlordimeform. Methomyl, pyrethroids and chlorpyrifos are more effective on Heliothis spp. moths than chlordimeform (Bell and Luttrell 1984, 1985).

Wolfenberger et al. (1974) showed that larvae exposed to sublethal doses of chlordimeform

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[illegible] or method."

[illegible]
and [illegible] [illegible] for
[illegible]
1977; [illegible] et al. 1981, [illegible]
1984, 1985, and 1986; [illegible]
[illegible] et al. 1986; [illegible] et al. [illegible]
[illegible] et al. [illegible]
including [illegible] [illegible]
carbonates, pyrethroids, [illegible]
and [illegible] [illegible]
[illegible]
[illegible] 1986 [illegible]
[illegible]
against [illegible] [illegible]
1971. [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
(Knowles [illegible]) [illegible] indicate [illegible]
rates of these three [illegible]
control [illegible] reduced costs. [illegible]
model [illegible]
[illegible] and [illegible]
mixtures of [illegible]
[illegible]
alternating [illegible]
[illegible]
[illegible] of chlordimeform [illegible]
resistance management [illegible] Section [illegible]
[illegible] of this report.

Acute Effects on Adults and Sublethal Effects on Adults and Larvae

Chlordimeform causes only low levels of adult [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
Chlordimeform

produced adult moths which exhibited reduced fecundity and reduced egg viability. Other sublethal effects of chlordimeform on both adults and larvae of _Heliothis_ spp. and other insects include: reduced feeding, hyperactivity, dispersal, inactivity and repellency (Doane and Dunbar 1973; Gemrich et al. 1976; Beeman and Matsumura 1978; Campbell et al. 1979; Salvisberg et al. 1980; and Knowles 1982). Roush (1986) reported that chlordimeform treatment caused second instar _H. virescens_ larvae to move about more than the other insecticides tested (methomyl, permethrin, fenvalerate, acephate, or chlorpyrifos). He suggests that this mobility brings the insects into contact with more toxicant, thus enhancing control.

f. Yield Enhancement

Chlordimeform is an effective yield enhancer. In 28 tests in Louisiana (39 separate comparisons from 1980 to 1985) 4 to 6 applications of chlordimeform enhanced yields an average of 7.6% (source: Louisiana State University Experiment Station and Cooperative Extension Service Demonstration Reports). This correlates with a report by Weaver and Bhardwaj (1985) which suggested that yields are increased an average of 60-70 lbs. per acre in the eastern half of the cotton belt by chlordimeform yield enhancement treatments. Since chlordimeform is less toxic to beneficial arthropods than alternative insecticides (see Section VIII D(1a) and VIII E(1) and suppresses secondary pest populations (see Section VIII D(1b), it is better suited for yield enhancement applications than the alternative compounds. A more detailed discussion of yield enhancement is included in another section of this report.

g. No Treatment

No treatment is an alternative to using insecticides on cotton. In certain parts of the cotton belt, for example the Texas and New Mexico High Plains, and some areas of the San Joaquin Valley of California, insecticide treatments may not be needed during some years on many fields. However, chemical control of pests is normally required to grow cotton profitably. This is illustrated by a summary of data from 29 small plot bollworm tests at the Louisiana State University Red River Research Station conducted between 1971 and 1985 (LSU Annual Reports 1971-1985). Comparing the untreated check with the

[illegible] (Lloyd [illegible]) [illegible]
[illegible] required [illegible] control [illegible]
[illegible] thus [illegible]

E. Yield Enhancement

Chlordimeform is an effect [illegible] 201 [illegible] 26 [illegible] in Louisiana [illegible] from 1980 to 1981 [illegible] chlordimeform [illegible] yield [illegible] (source: Louisiana [illegible]) [illegible] Station and Cooperative Extension [illegible] Demonstration reports [illegible] reported by Weaver [illegible] suggested that yields [illegible] of [illegible] per acre [illegible] cotton [illegible] by chlordimeform [illegible] yield enhancement [illegible] beneficial [illegible] insecticides (see section [illegible]) and [illegible] economic [illegible] (see section [illegible]), [illegible] yield enhancement [illegible] compounds [illegible] discussion of yield enhancement is included in another section of this report.

No Treatment

[illegible] alternative to [illegible]

highest yielding plot in each of these tests showed that the best treatment outyielded the check by an average of 42% (318 lbs. lint/acre). This figure is somewhat conservative for two reasons. First, some insect pest suppression occurs in the untreated check plots of small plot tests which are surrounded by treated plots. Second, when these test plots were infested by an insect pest which was not the subject of the investigation, all plots were sprayed with a selective insecticide. These data are sufficiently accurate to indicate that many cotton belt farmers have little alternative but to treat when damaging levels of pests occur in their fields.

2. Resistance Management

a. Situation

Historically, the management of cotton insect pests, particularly bollworm and tobacco budworm, has been hampered by the rapid development of resistance to insecticides used to control them (Sparks 1981, Georghiou and Mellon 1983). In the United States, bollworms and tobacco budworms have developed resistance to DDT and other organochlorines (Graves et al. 1963; Brazzel 1963; Graves et al. 1964; Brazzel 1964; Adkisson and Nemec 1966, Adkission 1969), methyl parathion (Nemec and Adkisson 1969, Nemec 1970, Graves et al. 1973, Lagunes et al. 1974, Brooks and Chambers 1975), methomyl (Graves et al. 1973, Mayeux 1976, Furr 1978, Martinez-Carrillo and Reynolds 1983, Roush and Wolfenbarger 1985), and some related insecticides.

Pyrethroids have been the principal insecticides used to control both bollworms and tobacco budworms in cotton since the late 1970's. Generally, these insecticides remain effective on bollworm and tobacco budworm although control problems have surfaced in the field, particularly in West Texas. Pyrethroids failed to control <u>Heliothis</u> spp. in cotton fields in several Texas cotton production areas in 1985 and 1986. Tobacco budworms collected in 1985 near Uvalde have been shown to be over 300 times more resistant than a susceptible laboratory strain (Plapp and Campanhola 1986). In the Imperial Valley of California, tolerance to pyrethroids increased not only seasonally but also steadily from 1979 through 1981 (Martinez-Carrillo and Reynolds 1983).

Fear of resistance to the pyrethroids in bollworm and tobacco budworm was heightened by the development of resistance in a closely related species, Heliothis armigera, to pyrethroids within two years of their introduction in Thailand (Wang and Boonkong 1981) and within six years of their introduction in Australia (Gunning et al. 1984). Furthermore, Gunning et al. (1984) found that cross-resistance was evidenced to all presently available pyrethroids.

Chlordimeform is an essential ingredient in resistance management to maintain the effectiveness of pyrethroids. Specific aspects of chlordimeform that merit discussion are:

1. Unique mode of action,

2. Synergism of pyrethroids and other insecticides and

3. Delaying or preventing the development of pyrethroid resistance.

b. Mode of Action

The mode of action of chlordimeform is unique among registered cotton insecticides. Because of its novel effects on insects and acarines (including those resistant to insecticides that have been used to control cotton pests) and its selective toxicity to most beneficial insects, chlordimeform is an essential component of most cotton pest management systems in the United States. Chlordimeform is so unusual in its biological actions that field activity against important lepidopterous pests such as the tobacco budworm and bollworm cannot readily be predicted through standard screening tests for pesticidal activity. The major difference between chlordimeform and conventional pesticides such as organophosphates and pyrethroids lies in the relative importance of sublethal and behavioral effects when compared to direct lethality (Hollingworth and Lund 1983).

Biological Responses to Chlordimeform

Chlordimeform at the dosages used on cotton does not exert a true ovicidal effect since embryonic development proceeds normally after exposure (Dittrich 1966, Wolfenbarger et al. 1974, Hollingworth 1976). Apparently larvae are killed as they chew their way through the chorion which absorbs chlordimeform. Some larvae that are able

[illegible] to the pyrethroids [illegible]
[illegible] has [illegible]
of resistance in [illegible]
[illegible]
two [illegible] introduced [illegible]
[illegible]
[illegible] (1984). [illegible]
found that [illegible]
presently available pyrethroids.

Chlordimeform [illegible] essential [illegible]
resistance management [illegible]
effectiveness of pyrethroids [illegible]
of chlordimeform [illegible] discussed [illegible]

1. Unique mode of action.

2. Synergism of pyrethroids and other insecticides and

3. Delaying or preventing [illegible] development of pyrethroid resistance.

b. Mode of Action

The mode of action of chlordimeform [illegible] among [illegible] its novel effects on insects and [illegible] (including the [illegible]) [illegible] have been used to control [illegible] (e.g., [illegible]) [illegible] toxicity [illegible] (1983). [illegible] is an essential component [illegible] pest management systems in the United States. [illegible] that field activity against [illegible] of pests such as the [illegible] cannot readily be [illegible] [illegible] potential [illegible] difference between [illegible] conventional pesticides such as [illegible] pyrethroids [illegible] [illegible] 1983).

[illegible] Responses to Chlordimeform [illegible]

[illegible] doses used on cotton [illegible]
[illegible] effect since [illegible]
[illegible]

to exit from eggs exposed to chlordimeform consume little food and die in 2-3 days. However, susceptibility to the lethal effects of chlordimeform declines rapidly after eclosion and larger larvae are relatively unsusceptible (Wolfenbarger et al. 1974, Gemrich et al. 1976). Important behavioral disruptions occur at very low doses (0.1-10 μg/g). These actions involve increased excitability and locomotor activity, which tend to result in larvae leaving the treated area (repellency), decreased feeding (antifeeding), and presumably the eventual death of the larvae through starvation and/or dehydration (Streibert and Dittrich 1977, Watanabe and Fukami 1977, Lund et al. 1979, Hollingworth and Lund 1982).

Adult lepidoptera are also extremely susceptible to chlordimeform. Hyperreflexia, hyperactivity and changed flight activity (flight during daytime hours) were observed in bollworm adults by Phillips (1971) at very low doses. Reproductive behavior is affected, such as inability to separate after mating and disruption of oviposition. Normal oviposition patterns are disorganized and eggs are scattered randomly, often on unsuitable oviposition sites, have also been reported (Phillips 1971, Salvisberg et al. 1980). At higher doses, chlordimeform induces wing beating and uncoordinated attempts at flight in tobacco budworm adults, which persist continually for many hours until the wings are shredded and the insects die, presumably from exhaustion and stress (Lund et al. 1971). Identical conclusions were reached by Salvisberg et al. (1980) for Spodoptera littoralis and by Watanabe and Fukami (1977) with Leucania separata. In addition, decreases in both the number of eggs laid and their viability have been observed (Phillips 1971, Wolfenbarger et al. 1974). These observations may be partly explained by recent findings by Linn and Roelofs (1984) that a non-lethal dose of chlordimeform reduces the response of the male Oriental fruit moth to the female phermone.

Beeman and Matsumura (1978) observed that chlordimeform at low doses (1 μg/g or less) caused a true anorexia (antifeeding) in the cockroach, Periplaneta americana. After injection of chlordimeform, starved cockroaches refused to eat and exhibited either a loss of appetite or arrested feeding behavior.

Thus, biological responses to chlordimeform range

[illegible] and [illegible] [illegible] susceptibility [illegible] [illegible] [illegible] decline [illegible] larvae [illegible] relatively [illegible] [illegible] 1974, [illegible] [illegible] (Sterz) [illegible] doses [illegible] [illegible] increased excitability [illegible] [illegible] tend to [illegible] [illegible] [illegible] depressed [illegible] [illegible] dehydration [illegible] Watanabe and Fukami 1977 [illegible] Hollingworth and [illegible]

Adult Lepidoptera are also exposed to chlorinated [illegible] and [illegible] flight activity [illegible] daytime [illegible] [illegible] [illegible] inability [illegible] [illegible] [illegible] normal [illegible] [illegible] often or [illegible] [illegible] 1977 [illegible] [illegible] wing [illegible] [illegible] in [illegible] [illegible] which [illegible] [illegible] for [illegible] [illegible] and the [illegible] [illegible] and stress [illegible] 1974 [illegible] [illegible] [illegible] In addition, [illegible] in both [illegible] [illegible] their viability have been [illegible] 1971, [illegible] [illegible] [illegible] [illegible] findings by [illegible] and [illegible] [illegible] lethal dose [illegible] [illegible] of the male [illegible] [illegible]

[illegible] [illegible] (1981) [illegible] [illegible]

from egg and small larval mortality (ovicidal, larvicidal, and adulticidal) to non-lethal effects (repellency, antifeeding, hyperactivity, and hypersensitivity resulting in mating disruptions, decreased oviposition, and decreased egg fertility).

Biochemical Aspects of Chlordimeform Action

Based on current knowledge, chlordimeform appears to have two general types of action on the nervous system, direct actions on excitable membranes and stimulation of neurotransmission at sites responsive to biogenic amines. Depending on the concentration and system under study, two different types of actions of chlordimeform have been observed on axonal and other excitable tissues. At relatively high concentrations (0.1-1.0 mM), formamidines act as local anesthetics, causing a depression of excitability. At lower doses, excitory effects on axons, characterized by destablization of the membrane potential, increased spontaneous activity, and repetitive discharge, have also been observed (Lund et al. 1979, Beeman and Matsumura 1974). Several reseachers suggest that formamidines have a primary action on biogenic amine systems (Aziz and Knowles 1973, Beeman and Matsumura 1973, Matsumura and Beeman 1976). Knowles and Aziz (1974) were the first to report the ability of formamidines to interact with biogenic amine receptors. It now appears that the octopaminergic actions of formamidines are the major biochemical action leading to the behavioral and toxicological effects observed in invertebrates. Thus the mode of action of chlordimeform is different from all other registered cotton insecticides.

c. Chlordimeform as a Synergist

Chlordimeform has been shown to synergize the toxicological activity of many insecticides including pyrethroids, organophosphates, carbamates, organochlorines, and insect growth regulators against tobacco budworms (Plapp 1976). The level of synergism is generally higher with pyrethroids than with other insecticides (Plapp 1976, 1979) against both bollworms and tobacco budworms. Furthermore synergism of pyrethroids by chlordimeform is greater against the tobacco budworm than against the bollworm and greater against resistant tobacco budworms than against susceptible laboratory strains (Plapp and Campanhola 1986).

[illegible] al., and [illegible] non-lethal [illegible] feeding, [illegible] activity, [illegible] sensitivity [illegible] decreased oviposition and [illegible]

Based on our present knowledge, chlordimeform appears to have two separate types of action [illegible] nervous system, [illegible] and [illegible] membranes and [illegible] receptors [illegible] Concentrations [illegible] different types of [illegible] been [illegible] tissues. [illegible] high concentrations, [illegible] causing a depression of [illegible] doses, [illegible] by destabilization of the [illegible] increased [illegible] activity [illegible] 1979 [illegible] researchers [illegible] primary [illegible] and [illegible] 1977 [illegible] were the first to report [illegible] receptors. [illegible] octopaminergic action [illegible] behavioral action [illegible] behavioral and [illegible] invertebrates. Thus [illegible] chlordimeform [illegible] different [illegible] selected cotton insecticides.

c. Chlordimeform as a Synergist

Chlordimeform has been shown to synergize [illegible] toxicological [illegible] activity [illegible] including [illegible] pyrethroids, [illegible] organophosphates, carbamates, [illegible] insect growth regulators [illegible] (1979). The [illegible] synergism [illegible] 1977) [illegible] [illegible]

For example, the addition of chlordimeform to permethrin (10:1 ratio) reduced the LD50 value for permethrin of a resistant tobacco budworm culture from West Texas (8 μg/vial) to the same value as that of a susceptible laboratory culture (0.5 μg/vial), i.e., a 16-fold reduction (Plapp and Campanhola 1986). Field observations in 1986 indicated that adding chlordimeform to pyrethroids increased their efficacy against tobacco budworm populations over that of pyrethroids alone.

Thus, chlordimeform when used in combination with pyrethroids is a means of maintaining the efficacy of the pyrethroids against resistant strains of *Heliothis* and of reducing the dosage level of pyrethroids against both susceptible and resistant strains. Reducing the dosage level of pyrethroids provides further selectivity in favor of beneficials such as *Chrysopa carnea* (Rajakulendran and Plapp 1982, Chang and Plapp 1983) and *Campoletis sonorensis* (Plapp 1979).

d. Delaying Pyrethroid Resistance Development

Using insecticides with different modes of action, either as mixtures or alternately, are suggested as ways of delaying resistance development. Recent modeling efforts indicate that mixtures will be more effective in delaying resistance development than alternating applications of the same pesticides (Knipling and Klassen 1984, Curtis 1985, Mani 1985). An assumption of the modeling studies is that part of the population is left unselected which is the case with bollworms, tobacco budworms and other cotton pests. Resistance to mixtures will develop very slowly if some RS heterozygotes are killed by one of the chemicals in the mixture, i.e., when the genes for resistance are recessive. Since pyrethroid resistance in tobacco budworm and other insects appears to be recessive in nature (Plapp 1976), then mixtures of pyrethroids with insecticides exhibiting different modes of action should be an excellent method for delaying resistance development.

Experimental evidence indicates that mixing chlordimeform with pyrethroids does indeed delay resistance development. Crowder et al. (1984) in a laboratory selection experiment with tobacco budworm increased the LD50 to permethrin 37 times in 11 generations of selection. In a comparison study where permethrin:chlordimeform (1:1) mixture was used as the selecting agent in 10 of

11 generations, the level of resistance to either permethrin or the mixture was not different from levels established in the F1. Additionally chlordimeform, acting as an ovicide, is equally effective against pyrethroid resistant and susceptible eggs (R.T. Roush, personal communications of unpublished data, 1986). Thus, chlordimeform could delay pyrethroid resistance development in at least two ways.

3. Economic Implications

The regional cost and yield changes projected by the team were processed with an econometric-simulation model to estimate the economic implications of the cotton insecticide scenarios. The model is an updated version of TECHSIM constructed by C. R. Taylor at the University of Illinois (Collins and Taylor 1983). The model simulates the production and marketing of major field crops including corn, soybeans, cotton, and feed grains. The current estimates parameters for cotton include a price of $0.697 per pound, production of 5.57 billion pounds, and 11.5 million planted acres. The model's estimated acreage is comparable to the 1981-84 average of 11.2 million planted acres. Estimated price is greater than the average of $0.60 for that period and much greater than the current cash price of $0.33 (Sept. 16, 1986). Provisions of the 1985 Farm Bill should cause future cotton prices to be lower than past prices as well as those projected by the model.

The model computes price, production, and acreage changes due to the cost and yield changes caused by policy or regulatory actions. It also simulates farmers' decisions to switch from one crop to another in response to price and profit changes. As a result, the effect of these actions are spread throughout the economy. The model also computes a number of economic welfare indicators including consumers' surplus and commodity producer income, net of variable costs, for a variety of crops. The concept of consumers' surplus is explained by the fact that some consumers are willing to pay more than the current market price for some of their purchases. Changes in consumers' surplus results in for consumer losses due to higher prices and lower production, that is, paying a higher price for a smaller quantity of a commodity. The model's estimates of consumers' surplus changes include economic impact in the marketing chain on cottonseed, oil, and meal. This economic evaluation discusses changes in cotton price, production, acreage, and welfare changes resulting from the three cotton scenarios.

Changes in average returns for users and nonusers of the chemical(s) in question are computed from the model results. It is assumed that users of the chemical(s) in question absorb all yield and cost changes, while price changes affect nonusers' returns. All acreage reductions come from the area treated with the chemical(s). (See Appendix D).

Reasons for the projected changes in cotton yield and insect control costs for the three scenarios are: (1) Alternative insecticides would be less effective in controlling key target pests. (2) Higher rates and closer application intervals of more expensive and more acutely toxic alternative insecticides would often be necessary. (3) Secondary pest problems would increase. (4) Changes in cultural practices would shorten the growing season to avoid pests and would subsequently reduce cotton yields.

Effects of losing chlordimeform

The team estimated that cotton yields would decrease an average of 2.1% per acre while costs increase an average of $4.74 per acre across all U.S. cotton (Table VIII D 3(1)). Average yield and cost changes are also displayed for various regions in Table VIII D 3(1). The yield losses range from 9% in the Southeast to almost none in the Missouri Bootheel and the West.

As a result of losing chlordimeform, total cotton production would decrease by about 4% and planted acreage by less than 1% (Table VIII D 3(2)). The decreased production would cause cotton prices to increase by about $.04 per pound which, in turn, would increase income to cotton producers, net of variable costs, by $37 million. However, the users of chlordimeform will lose about $33 per acre, while cotton producers not using chlordimeform will gain about $17 per acre from higher prices. American consumers will suffer a loss of about $193 million with a resulting net domestic loss of $156 million.

Effects of losing of chlordimeform and pyrethroids

Chlordimeform exhibits synergistic effects, retards the development of resistance to pyrethroids in theoretical models and a laboratory experiment, and is a better alternative for early season yield enhancement applications in an IPM sense. Thus, the team estimated the effects of pyrethroids becoming ineffective through resistance due to removing chlordimeform from the market. The panel estimated that cotton yields would decrease an average of 13.2% in the U.S., 11.1% points more than losing only

[illegible] use and resources in [illegible] are compared with the [illegible]

[illegible] the [illegible] Appendix [illegible]

Reasons for the projected changes in cotton [illegible] insect control costs for the three [illegible]: (1) Alternative insecticides would be less [illegible] in controlling key target pests, (2) Higher rates [illegible] closer application intervals [illegible] must [illegible]: acutely toxic alternatives [illegible] would often be necessary, (3) [illegible] would increase, (4) Changes in cultural practices would shorten the growing season [illegible] subsequently reduce cotton yields.

Effects of losing chlordimeform

The [illegible] estimated that cotton [illegible] an average of 2.[illegible] per [illegible] average of [illegible] per acre [illegible] (Table VIII C 3(1)). [illegible] yield [illegible] are also displayed [illegible] C 3(1). [illegible] Southeast to almost none in the Mississippi Delta and the West.

As a result of losing chlordimeform, total [illegible] would decrease by [illegible] (Table [illegible] C 3(1)). [illegible] would cause cotton prices to increase about $.04 per pound [illegible] increase income to cotton producers [illegible] by $57 million. However, the users of chlordimeform will lose about $53 million, while producers not using chlordimeform will [illegible] million from higher prices. American [illegible] will suffer a loss of about [illegible] million [illegible] net domestic loss of [illegible] million.

[illegible] cost of chlordimeform on [illegible]

[illegible] resistance to [illegible] laboratory experiments [illegible] relative [illegible] yield [illegible] TMV [illegible]

chlordimeform (Table VIII D 3(1)). The team also estimated that costs would increase $13.26 per acre, approximately $8.52 more than losing only chlordimeform.

These yield and cost changes would decrease cotton production by 15% and acreage by 2% (Table VIII D 3(2)). Cotton price would increase approximately $0.18 per pound, and the income of cotton producers (net of variable costs) would increase by $188 million. Users of these chemicals would lose an average of $71 per acre, while cotton producers not using the chemicals will gain an average of $86 per acre from higher prices. However, domestic consumers would lose about $947 million. The net domestic loss of $759 million would be $603 million greater than losing only chlordimeform. Such a joint effect between chlordimeform and the pyrethroids shows that chlordimeform could have benefits considerably greater than the $156 million estimated in the previous scenario, since it helps to maintain the effectiveness of pyrethroids.

Effects of losing pyrethroids only

This scenario, when compared with the previous scenario, approximates the benefits of chlordimeform in the absence of pyrethroids. The panel estimated that cotton yields would decrease by 10.2% in the U.S., which is 3% points less than losing both chlordimeform and the pyrethroids (Table VIII D 3(1)). Costs would increase by $13.19 per acre, about the same as losing both.

Losing the pyrethroids would cause cotton production to decrease by 13% and acreage by 2%. The result would be an increase in cotton price of approximately $0.15 per pound. This is $0.03 per pound less than the increase would be from losing chlordimeform and pyrethroids. The income to cotton producers, net of variable costs, would increase by $154 million. Users of the pyrethroids will lose an average of about $66 per acre, while producers not using pyrethroids would gain about $71 per acre from price increases. Domestic consumers would lose $787 million (Table VIII D 3(2)). The net domestic loss would be $633 million which is $126 million less than losing the pyrethroids and chlordimeform. Hence, the economic benefits of chlordimeform are comparable whether pyrethroids are available or not. However, chlordimeform could have a considerably greater benefit in preventing the development of resistance to pyrethroids.

Prices, yield and cost [illegible] would [illegible] increase [illegible] [illegible] by 15% at 1 acre [illegible] 3(2)). Current price [illegible] [illegible] [illegible] [illegible] per pound, and the [illegible] [illegible] that of variable cost [illegible] would [illegible] [illegible] Users of these chemicals would [illegible] average of [illegible] per acre [illegible] [illegible] using the chemicals w [illegible] [illegible] higher prices. However, [illegible] would lose about [illegible] billion, [illegible] [illegible] of [illegible] million would be [illegible] [illegible] [illegible] [illegible] [illegible] losing on [illegible] [illegible] [illegible] chlordimeform [illegible] prices [illegible] chlordimeform could have benefits [illegible] greater than the [illegible] million [illegible] [illegible] [illegible] [illegible] it being [illegible] effectiveness of pyrethroid.

Effects of Losing Pyrethroid [illegible]

This [illegible] [illegible] [illegible] [illegible] condition, [illegible] [illegible] [illegible] the absence of pyrethroids. [illegible] that cotton yields [illegible] [illegible] [illegible] U.S. [illegible] [illegible] chlordimeform are the [illegible] 3(1)). This would increase [illegible] [illegible] about the same as [illegible]

Losing the pyrethroids would cause [illegible] production to decrease by [illegible] and average [illegible] [illegible] increase in cotton price of approximately [illegible] per pound. This is [illegible] per pound [illegible] [illegible] [illegible] [illegible] [illegible] variable costs, would increase [illegible] Users of the pyrethroids will [illegible] [illegible] about [illegible] per acre, while [illegible] [illegible] [illegible] [illegible] would gain [illegible] [illegible] decreases. Domestic consumers [illegible] [illegible] [illegible] table [illegible] [illegible] [illegible] [illegible] million which is [illegible] [illegible] [illegible] pyrethroids [illegible] [illegible] [illegible] benefits of [illegible] [illegible] [illegible]

Table VIII D 3(1). Average annual per acre yield and cost changes for cotton insecticide scenarios

Region	Lose chlordimeform: Yield loss	Lose chlordimeform: Cost change	Lose chlordimeform and pyrethroids: Yield loss	Lose chlordimeform and pyrethroids: Cost change	Lose pyrethroids: Yield loss	Lose pyrethroids: Cost change
	Percent	Dollars per acre	Percent	Dollars per acre	Percent	Dollars per acre
Appalachia	5.1	-1.11	14.1	5.35	11.4	10.26
Corn belt	0	17.38	15	33.99	15	-2.12
Delta	1.9	10.19	13	41.93	11	34.41
Mountain States	4.7	41.82	23.7	23.95	20.8	31.98
Southeast	8.9	9.10	39.1	37.05	26.7	34.54
Southern Plains	1.2	- .05	12.6	2.49	9.3	4.65
West	.3	-1.28	2.3	- .79	1.4	1.52
U.S.	2.1	4.74	13.2	13.26	10.2	13.19

Appalachia: North Carolina, Virginia, Tennessee
Corn belt: Missouri
Delta: Arkansas, Louisiana, Mississippi
Mountain States: Arizona, New Mexico
Southeast: Alabama, Florida, Georgia, South Carolina
Southern Plains: Oklahoma, Texas
West: California

Table VIII D 3(2). Summary of annual economic effects

Effect on cotton	Scenario		
	Lose chlordimeform	Lose chlordimeform and pyrethroids	Lose pyrethroids
		Dollars per pound	
Price change	+0.035	+0.177	+0.147
		Percent	
Acreage change	- .8	-1.8	-2.1
Production change	-3.6	-14.7	-12.6
		Million Dollars	
Welfare changes:			
Farm income (cotton)	+37.40	+187.84	+154.02
Domestic consumers' surplus	-193.37	-946.93	-787.40
Net domestic effect	-155.97	-759.09	-633.38
		Dollars per Acre	
Cotton producer effects:			
Users of scenario chemicals	-33.	-71.	-66.
Nonusers	+17.	+86.	+71.

E. Exposure and Risk

1. Evaluation of Exposure and Hazard to Bees, Predators, Parasites and Other Beneficial Organisms

Bees

There is lack of agreement on the importance of bee

pollination in cotton (McGregor 1976). Present emphasis on setting and retaining early cotton fruit should increase this importance. Bee pollination can increase fruit set, since inadequate pollination is one of the causes of fruit shed (McGregor 1976). Other potential benefits from bees in cotton include: greater lint and seed production, earliness of harvest, and fewer motes (ovules that fail to develop into seeds with well-developed, ginnable fibers). Cotton, in turn, provides a nectar source to bees at a time when few other sources are available in some areas. This has economic implications to the honey bee industry.

The effect of pesticides on honeybees is well documented. Atkins et al. (1981) classified chlordimeform as relatively nontoxic to bees, while methomyl, another insecticide with ovicidal activity is highly toxic. Atkins et al. (1975) showed 8.49% honey bee mortality at 114.85 micrograms of chlordimeform per bee. This LD50 value of chlordimeform in micrograms per bee is the equivalent of 115 kg AI per hectare (102 lbs/ai/A). The highest rate presently labeled for field use is 0.25 lbs/ai/A. Waller (1986) reported 0 to 2% mortality when honey bees contacted leaves immediately after they were sprayed with chlordimeform. This mortality was identical to mortality recorded in the untreated check. By contrast, insecticides in the highly toxic group gave 76 to 100% mortality in the same test.

Research data indicates that chlordimeform should have no detrimental effects on bees in the quantities they would encounter in field situations. Research by Dr. Niko Koeinger provides dramatic proof of chlordimeform's low toxicity to bees. He controlled the *Varroa* mite in honey bee colonies being fed a sugar solution containing chlordimeform (Waller, 1986).

Entomophagous Arthropods

The importance of natural populations of entomophagous arthropods (beneficials, parasites and predators) in suppressing cotton insect pests has been reviewed by Newsom and Brazzel (1968) and Ables et al. (1983). The conservation of parasites and predators has been stressed in IPM research and demonstrations (Ables et al. 1983; Roof and Jones 1986; and Turnipseed and Sullivan 1986).

Pitts and Pieters (1982) caged four species of beneficial insects (*Geocoris* spp., *Nabis* spp., *Hippodamia convergens* and *Chrysopa carnea*) on plants treated with chlordimeform at 0.125 lbs/ai/A,

methomyl at 0.125 lbs/ai/A and untreated plants. There was no significant difference in mortality between beneficials on untreated plants and those on plants treated with chlordimeform. Mortality of all four species was greater on methomyl treated plants than on untreated plants.

Rajakulendran and Plapp (1982) reported that chlordimeform was highly toxic to Chrysopa carnea larvae. This was based on a laboratory test where larvae were exposed to 25.04 g chlordimeform in glass vials or the equivalent of 25 lbs/ai/A or 100 times the normal field usage.

Tests conducted in field cages by Lingren and Wolfenbarger (1976) showed that up to 3 applications of chlordimeform at rates of 0.6 to 0.8 lbs/ai/A had no effect on Orius insidiosus. Lingren and Wolfenbarger (1976) and Bull and Coleman (1985) found that populations of Trichogramma spp., an egg parasite, was relatively tolerant to chlordimeform in tests conducted on caged plants. Mortality of the host eggs from applications of an ovicide would be expected to have some adverse effect on Trichogramma populations. Powell et al. (1986) found no dosage-mortality response with 2500 ng/insect in laboratory tests on Microplitis croceipes, a larval parasite.

Field studies by Benedict et al. (1986) concluded that 4 and 7 applications of 0.125 lbs ai/A had no significant effect on predaceous insects and spiders. Jones (1986) found in large field studies that when three treatments of chlordimeform at 0.250 lbs/ai/A were applied at 5-day intervals, the predaceous insect population was devastated, but spiders were not affected (Orius insidiosus was not present). Graves (1986) reported similar observations. Where initial treatments of chlordimeform at 0.250 lbs/ai/A were followed by subsequent treatments at 0.125 lbs/ai/A, there were no apparent effects on the predaceous arthropods (Jones 1986).

The usefulness of chlordimeform as a tool in IPM programs in cotton was stressed by both manufacturers (Ciba-Geigy and NOR-AM) in a report to EPA entitled, "The Benefit Assessment for Chlordimeform - July 15, 1986." Work by Bull and House (1978) and Pieters et al. (1978) has been directed toward using chlordimeform against Heliothis spp. alone or in combination with biological insecticides containing either Baculovirus heliothis or Bacillus thuringiensis.

The Arkansas NSF/EPA project by Phillips and Nicholson (1978) utilized chlordimeform and

biological insecticides in a community IPM program. Phillips (1978) reduced chemical insecticide inputs by 80%. The key ingredient was chlordimeform used community-wide at peak Heliothis spp. oviposition. Chlordimeform was chosen because of its ovicidal action and lack of phytotoxic effects to cotton and the absence of detrimental effects on beneficial predators and parasites which suppress various cotton pests. The boll weevil was not a problem in the area during the study period.

Bell (1983) reported success in controlling Heliothis with biological insecticides in the absence of the boll weevil. The combination of a biological insecticide, chlordimeform, and entomophagous arthropods is being studied in South Carolina by Roof and Jones (1986) and Turnipseed and Sullivan (1986). Where boll weevils are no longer of economic importance due to the eradication effort in the Carolinas, this method shows promise for the future.

2. Exposure, Risk and Use Restrictions

Exposure Assessment in Agricultural Workers

When chlordimeform was reintroduced as a cotton insecticide, EPA required Ciba-Geigy and NOR-AM to monitor metabolite residues in the urine of workers. (Anon. 1986).

Between 1978 and 1981, monitoring studies were performed on workers who were required to wear the protective clothing as described on the label (Appendix B). 1986). Average daily exposures were as follows: 51% were below the 0.05 ppm level of detection; 33% were between 0.05 and 0.29 ppm; 10% were between 0.30 and 0.99 ppm; and 5% were at 1.00 ppm or more. Workers in the Southeastern U.S., the Southern high plains of Texas and Mississippi Delta cotton areas all showed similar levels of exposure. Worker exposure values from similar studies by the California Department of Food and Agriculture (CDFA) (Anon. 1986) and the British Agrochemicals Association (BAAL) (Anon.1986) produced risk values that were somewhat lower.

An earlier report by Ciba-Geigy in 1976 and 1977 compared chlordimeform metabolites in urine for workers with little or no protective measures to workers who used extensive protective measures. Those who used the protective measures, later adopted for the reintroduction program, showed 3.6 fold decrease in exposure to chlordimeform.

Acute Toxicity

Insecticides in a community [illegible] 171 [illegible]
[illegible] reduced natural enemies [illegible]
the key factor [illegible]
[illegible] weak [illegible] egg [illegible] oviposition
[illegible] was chosen because of its [illegible]
action and lack of phytotoxic effects to cotton
[illegible] of detrimental effects [illegible]
[illegible] and parasites which [illegible]
pests. The boll weevil was not a problem in the [illegible]
during the study period.

Bell (1980) reported success in controlling [illegible]
with biological [illegible] in the cases of [illegible]
boll weevil. The combination [illegible] biological
insecticides. [illegible]
[illegible] South Carolina [illegible]
[illegible] (1980) and [illegible] Sullivan [illegible]
[illegible] boll weevils [illegible] no longer [illegible]
[illegible] the eradication effort [illegible]
[illegible], this method shows promise for [illegible]

Exposure Risk and Use Restrictions

Exposure Assessment in Agricultural Workers

When chlordimeform [illegible]
[illegible] for required [illegible] and [illegible]
monitor [illegible] metabolite [illegible] the urine of workers [illegible]
[illegible] 1980).

Between 1975 and 1981, monitoring studies [illegible]
[illegible] who were [illegible]
[illegible] as [illegible]
[illegible]. Average daily exposures [illegible]
[illegible] 0.05 [illegible] level of
detection) [illegible] were between 0.05 and [illegible]
were between [illegible] and [illegible]
[illegible] workers in the Southeast [illegible]
[illegible] High [illegible] of [illegible] and [illegible]
[illegible] all [illegible] levels of exposure
were exposure [illegible]
California Dept. of Food and Agriculture (CDFA,
[illegible] British [illegible] Agrochemicals
[illegible] (1976) [illegible]

[illegible] 1976, and 1977
[illegible]
[illegible] measures [illegible]
[illegible]

Acute toxicity symptoms of chlordimeform in man are known as the result of physical examinations performed on a number of workers who were exposed to high levels of chlordimeform while working in a formulation plant in 1975 (Hayes 1982). Their symptoms included skin rash, abdominal pain, urinary urgency and frequency, dipuria, nocturia, and urethral discharge. The three workers most seriously affected were hospitalized. All three had reduced bladder capacities and two had urethral reflux. Cystoscopy revealed that all had hemorrhagic cystitus. In most patients, urinary illness persisted for 4-14 days. The urinary illness lasted about two months in the three individuals who were hosptialized.

Incidents of chlordimeform poisoning in workers are rare. The EPA stated that there have been no reported human poisoning cases on the Agency's Pesticide Incident Monitoring System other than the incident mentioned above which occurred in a formulation plant (Anon. 1986).

The Medical University of South Carolina operated the National Pesticide Telecommunication Network from early 1979 through April 1, 1984. The Network operated as a service to health professionals who dealt with cases of accidental poisonings. During that time period, approximately 12,000 calls were received and of these, only three involved exposure to chlordimeform; two were acute poisonings and one skin rash (Dr. Samuel Caldwell, personal communication 1986).

Apparently, there have been no instances where workers have received a life threatening exposure to chlordimeform. The only reported mortality occurred in a suicide victim who ingested 30 ml of a 50% formulation of chlordimeform, the equivalent of 214 mg/kg (Hayes 1982).

Chronic Toxicity and Risk Assessment

The EPA has classified chlordimeform and chlordimeform HCL as "probable human carcinogens" based upon data submitted to the Agency and involving four chronic feeding studies in mice. Chlordimeform HCL and their metabolites caused significant increases in number of hemangioendotheliomas and hemangiomas in mice when included in diets at levels as low as 100 ppm. Similar studies with rats failed to demonstrate that chlordimeform and chlordimeform HCL or their metabolites were oncogenic.

[illegible] [illegible] [illegible] [illegible], [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] a number of workers who were exposed to high levels of chlordimeform while working in [illegible] [illegible] [illegible] in 1975 (Ha [illegible] 19[illegible]). The symptoms included skin rash, abdominal pain, urinary urgency and frequency, dysuria, hematuria, and urethral discharge. The three workers most seriously affected were hospitalized. All three had reduced bladder capacities and two had urethral lesions. Cystoscopy revealed that all had hemorrhagic cystitis. In most patients, urinary illness persisted for 4-14 days. The urinary illness lasted [illegible] two months in the three individuals who were hospitalized.

[illegible] incidents of chlordimeform poisoning in workers [illegible] [illegible] the EPA stated that there have been no [illegible] reported human poisoning cases in the [illegible] Pesticide Incident Monitoring System other than the incidents mentioned above which occurred in a formulation plant (Anon. 1976).

The Medical University of South Carolina operated the National Pesticide Telecommunication Network from early 1978 through April 1, 1984. The Network operated as a service to health professionals who dealt with cases of accidental poisonings. During that time period, approximately 12,000 calls were received and of these, only three involved exposure to chlordimeform; two were acute incidents and one skin [illegible] (Dr. Samuel [illegible], personal communication 1986).

Apparently, there have been no instances where workers have received a life threatening exposure to chlordimeform. The only reported mortality occurred in a [illegible] who ingested 30 ml of a [illegible] formulation [illegible] [illegible] storm, the equivalent of [illegible] mg/kg [illegible].

[illegible] Toxicity and Risk Assessment

[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] NCL as [illegible] [illegible] [illegible]
[illegible] submitted to the Agency and involving [illegible] feeding studies in mice. This [illegible]
[illegible] [illegible]
[illegible]

EPA reviewed chronic feeding studies in mice, and assigned a potency value of 1.0 mg/kg/day to chlordimeform which was used in developing the risk assessment for carcinogenicity of chlordimeform to workers who are presented in Table A.

Apparently no risk assessment studies have been made for operators of ground equipment who apply chlordimeform. This information is certainly needed since a large portion of current applications are made with ground equipment.

Table A. EPA Risk Assessment for Workers(1)

Worker Category	Agency Data Base	CDFA Studies	BAAL Studies
Mixer/ loaders	4×10^{3} (10.3)(2)	1×10^{5} (0.03)	3 x 10-3 (8.3)
Pilots	8×10^{5} (0.2)	4×10^{5} (0.1)	-
Flaggers	2×10^{4} (0.6)	8×10^{7} (0.002)	-

(1) These values are for the upper 95% level for a B2 oncogen classification. They also reflect an estimated life expectancy of 70 years and 35 years working lifetime. The potency factor for chlordimeform is assumed to be 1.0. Dermal penetration is assumed to be 30% according to preliminary human studies.

(2) Values in parenthesis are yearly exposure values in mg/kg/year from worker studies.

3. Limitations on Chlordimeform Use

Several restrictions placed on the use of chlordimeform by EPA in 1978 have served to reduce exposure to workers. Since chlordimeform was reintroduced in 1978, it has been restricted to use on cotton. Workers who apply chlordimeform are required to be certified or to work under the supervision of a certified applicator.

Applicators, mixers and loaders are advised on the chlordimeform labels to wear the following protective clothing: heavy duty, long-sleeve, one-piece work suit, cloth cap; underwear, including T-type undershirt; heavy-duty fabric rubber or neoprene-type gloves; socks; heavy-duty work boots (waterproofed); and goggles or face shield.

A closed system is required during transport, transfer and mixing of chlordimeform. The closed system is defined as appropriate connections, meters, pumps and plumbing designed to eliminate human contact. The SP formulation in soluble packets largely negates the need for a closed system except where a separate mixing tank is used. Then, the mixture must be transferred to the spray tank via a closed system.

The maximum application rates for chlordimeform on cotton have been reduced from 1.0 to 0.25 lb/ai/A. The range in label rates is 0.125 to 0.25 lb/ai/A in all states except in California where 0.25 lb. is recommended.

In 1978, chlordimeform was limited by EPA to aerial use alone and flagmen were prohibited. Ground equipment has been approved for application since 1983. Low drift nozzles are required for application by ground and air.

Workers are advised not to enter treated fields for at least one day following the application of chlordimeform.

Other restrictions and precautions are included on chlordimeform insecticide labels, but those mentioned above may have the greatest impact in limiting exposure to workers.

State Requirements for the Use of Chlordimeform

All cotton growing states except California have adopted the EPA restrictions regulating the use of chlordimeform on cotton. California has placed additional application and medical monitoring limitations on use of chlordimeform as detailed in Appendices B and C.

systems [illegible] chloroform. [illegible] [illegible] aircraft [illegible] [illegible] and [illegible] designed to eliminate [illegible] contact [illegible] of formulation [illegible] largely negates the need for a closed system, [illegible] where a separate mixing tank is used. [illegible] requires [illegible] transfer [illegible] to the mixing tank [illegible] closed system.

The maximum application rates for chlordimeform [illegible] cotton have been reduced from [illegible] 0 to 0.5[illegible] lb. The [illegible] range on label rate is 0.12 [illegible] 0.25 [illegible] all states except in California where 0.25 [illegible] is recommended.

In 1976, chlordimeform was limited [illegible] use [illegible] by [illegible] flagmen were [illegible] equipment has been approved [illegible] 1983. Low drift nozzles [illegible] required for [illegible] by ground and air.

Workers are advised not to enter treated fields [illegible] at least one day following the application of chlordimeform.

Other restrictions and precautions are [illegible] on all chlordimeform insecticide labels, [illegible] above [illegible] have [illegible] greatest impact [illegible] limiting exposure to workers.

State [illegible] for the [illegible] chlordimeform

All cotton growing states except California have adopted the EPA restrictions [illegible] the use of chlordimeform on cotton. California [illegible] restricted application and medical monitoring regulations on use of chlordimeform, detailed in [illegible]

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Appendix A

Major Arthropod Pests

Thrips

A complex of thrips species, *Thrips* spp., *Frankliniella* spp., *Sericopthrips* spp. and *Scolothrips* spp. feed in the terminals of seedling cotton plants where they cause deformation of developing leaves. Thrips are particularly damaging during cool spring weather when plant growth is slow. Later in the season plants are able to outgrow this damage, even in the presence of large numbers of thrips.

Thrips are very slender-bodied yellowish to brownish insects. The bristly-winged adults are only 1/25th inch long. Both adults and nymphs rasp the epidermis of leaves and buds and suck plant sap that exudes from injured tissue. Thrips feeding has been observed to cause abortion of fruit in the mid-south and southwestern areas of the U.S. Western flower thrips, *Frankliniella occidentalis* prey on eggs of spider mites in the western cotton growing regions of the U.S.
Thrips are often controlled on a preventative basis where there is a history of heavy populations and damage potential. Treatments are applied at planting as granular systemics or by application of foliar sprays. Protection from damage is also important for the crop to attain sufficient size for post-emergent herbicide application.

Plant Bugs

Several species of plant bugs attack cotton. The most common pests are two species of lygus bugs, the tarnished plant bug (*Lygus lineolaris*), a western species (*L. hesperus*), and the cotton fleahopper *Pseudatomoscelis seristus*). Several other species attack cotton in various areas of the cotton belt, but are of less economic importance. These pests have numerous native weed and crop hosts from which they migrate to cotton during much of the growing season. Damage is caused by puncturing the plant tissues with piercing-sucking mouthparts. In addition to the physical injury and the removal of plant fluids, a toxic reaction to plant cells near the puncture results from their feeding. Upon initiation of fruiting, plant bugs feed on small squares (flower buds) developing in the terminal of the plant, thus causing fruit abortion. Severe damage from these pests may cause a condition called "crazy cotton" in which plants lose terminal dominance characterized by rapid vegetative growth. Plant bug feeding results in delayed fruiting and reductions in yield and fiber quality.

Plant bugs are controlled with several types of insecticides and resistance to some organophosphate and carbamate compounds has developed in various parts of the cotton belt.

A complex of thrips species, [illegible] [illegible] cotton seedlings [illegible] [illegible] [illegible] during [illegible] seedling cotton plants [illegible] [illegible] developing leaves. [illegible] [illegible] [illegible] [illegible] weather when [illegible] growth is [illegible] [illegible] plants are able to outgrow [illegible] presence of [illegible] numbers of thrips.

Thrips are very slender-bodied [illegible] [illegible] the [illegible]-wing [illegible] adults are only [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] cotton plant [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] has been observed to cause [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the western cotton [illegible] [illegible] controlled on a [illegible] [illegible] [illegible] history of heavy [illegible] Treatments are applied at planting [illegible] [illegible] application of [illegible] [illegible] [illegible] [illegible] of the crop [illegible] [illegible] post-emergent [illegible] application.

Plant Bugs

Several species of plant bugs attack cotton [illegible] pests are [illegible] of *Lygus* [illegible] [illegible] [illegible] a western [illegible] [illegible] [illegible] [illegible] cotton in [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] economic [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] weed and crop [illegible] [illegible] [illegible] [illegible] the plant [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] feeding. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] fruiting and [illegible]

Boll Weevil

The boll weevil, Anthonomus grandis, is probably the most notorious of all insect pests attacking row crops. Since its invasion of the U.S. from Mexico in 1909, it has caused countless millions of dollars of losses to the cotton industry. Historically, boll weevils were found only from central Texas eastward. It has recently become a pest of cotton in Arizona and the southeastern desert production area of California.

Cotton squares (flower buds) are the preferred feeding and oviposition site of boll weevils although developing bolls are readily attacked. Immature boll weevils are concealed inside squares or bolls until ready for adult emergence. Their feeding causes squares to drop from the plant renders bolls unless for harvest.

Management of the boll weevil in areas of traditionally high infestation levels dictates the need for fall diapause control and timely stalk destruction to reduce overwintering populations. Early season applications of insecticide are also needed to further reduce the populations. With fewer weevils to reproduce, some loss of cotton may be prevented and certainly fewer in-season applications of insecticide are needed for their control. Where in-season populations are extremely high, applications must be made on a 3-4 day interval to break the population cycle. Fortunately, insecticides that effectively controlled the boll weevil 25 years ago still provide good control.

Bollworm Complex

The bollworm, Heliothis zea, and tobacco budworm, H. virescens, attack cotton through most of the cotton belt. They are currently considered to be the most damaging of all arthropod pests of cotton. Eggs are laid on terminal leaves, older leaves, branches, square bracts or blooms. As young larvae emerge, they begin to feed on the tender plant tissue near their hatching site. If located in the terminal, they often bore into the terminal destroying several small squares and meristematic tissue that produce later squares. As the larvae develop, they begin moving about the plant feeding on squares, blooms and bolls. An individual larvae may destroy most fruit on a plant. Once larvae begin to move about the inner plant canopy, control is difficult to achieve.

Several generations of these pests may occur in cotton in any given year depending on the geographical location. Large invasions of adults may occur from other crops or from native vegetation in the area. There is also an indication that massive numbers of adults may migrate long distances to infest cotton where existing bollworm populations have not already reached economically damaging levels.

The boll weevil. Before the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] all insect pests [illegible] [illegible] invasion of the U.S. from Mexico in 1892, [illegible] [illegible] millions of dollars [illegible] [illegible] [illegible] [illegible] [illegible] boll weevil [illegible] [illegible] [illegible] [illegible] Texas [illegible] [illegible] [illegible] cotton [illegible] [illegible] [illegible] of California.

Cotton [illegible] [illegible] [illegible] the pesticide [illegible] [illegible] [illegible] boll weevil [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] from [illegible] plant [illegible] boll [illegible] [illegible].

[illegible] of the boll weevil in areas of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] on the [illegible] cotton [illegible] [illegible] weevils [illegible] the population [illegible] [illegible] insecticides that effectively control the boll weevil [illegible] [illegible] still provide good control.

Boll Worm Complex

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of cotton. Eggs are laid on [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] occur in cotton in any [illegible] location. [illegible] [illegible] crops [illegible] [illegible] [illegible] [illegible] [illegible]

Heliothis spp. populations lend themselves well to various management strategies; however, insecticides remain the first line of defense against damage caused by these pests in most areas of the cotton belt. The bollworm complex is effectively controlled by beneficial insects in some areas if biological control is not disrupted. While insecticides are widely used against these pests, resistance to several organochlorine, organophosphate and carbamate insecticides has occurred. There is also evidence of resistance to pyrethroid compounds in several areas. One tool that has been successfully used for the last 15 years is the use of ovicides to reduce the population of *Heliothis* spp. to levels that are either below the economic threshold or are more manageable with conventional insecticides. Current control across the cotton belt is with the ovicide chlordimeform, pyrethroids, and certain organophospate and carbamate materials or combinations of these.

Armyworm Complex

The fall armyworm, *Spodoptera frugiperda*, and beet armyworm, *S. exigua*, are defoliators, but in cotton they feed heavily on squares, blooms and young bolls. In the absence of sufficient predators or timely applications of insecticide, these pests may totally destroy the crop if populations are high.

Unlike the bollworm complex, the armyworms lay their eggs in a mass of up to 100 eggs. The eggs are generally laid on the underside of leaves in the lower portion of the plant canopy and are covered with scales from the moths body. Newly emerged larvae generally feed for at least a short time on foliage, but later move to fruiting structures causing extensive damage when populations are high.

Aside from being very difficult to control with currently used conventional insecticides (depending on region), their habit of remaining in the lower portion of the plant affords them additional protection. Both species are resistant to most insecticides in various sections of the country. Where chlordimeform is used in a control program against the bollworm complex, armyworms have been effectively suppressed.

Pink Bollworm

The pink bollworm, *Pectinophora gossypiella*, is a major pest of cotton in the southwestern and western desert areas of the U.S. excluding the San Joaquin Valley of California. Eggs are deposited on squares primarily beneath the calyx cup of bolls 12-20 days of age. Emerging larvae destroy some blooms, but principal damage is done when larvae penetrate the bolls, feed on developing seeds and cut lint as they move from seed to seed.

[illegible] has long been [illegible] various [illegible] insecticides [illegible] the first [illegible] caused by [illegible] [illegible]. The bollworm [illegible] [illegible] beneficial insects [illegible] but their control is not improved, while insecticides [illegible] used against these pests, particularly [illegible] [illegible] have appeared. Since [illegible] pyrethroid compounds in [illegible] [illegible] been successfully used for the last 15 years [illegible] [illegible] the population [illegible] that are [illegible] below the economic threshold [illegible] [illegible] insecticides. [illegible] cotton [illegible] is [illegible] pyrethroids, [illegible] certain [illegible] [illegible] combinations of these.

[illegible]

The fall armyworm, [illegible] frugiperda, [illegible] S. exigua, [illegible] [illegible] the crop if populations are high.

Unlike the bollworm complex, the armyworms lay their eggs in masses of up to 1,000 eggs. The eggs are generally laid on the underside of leaves in the lower portion of the plant canopy [illegible] and larvae [illegible] but later move to [illegible] structures [illegible] extensive damage when populations are high.

[illegible] very difficult to control with currently used conventional insecticides (depending on region). [illegible] [illegible] are resistant to [illegible] in various sections of the country. [illegible] used [illegible] control [illegible] armyworm have been effective [illegible].

PINK BOLLWORM

[illegible] (Pectinophora gossypiella), is a major pest [illegible] [illegible]

A fungus, _Aspergillus flavus_, which produces aflatoxin, invades infested bolls. In areas of severe pink bollworm infestations, aflatoxin may present a health hazard to cotton ginners and seed mill workers and to livestock fed seed and seed products.

Since there are no effective natural enemies of the pink bollworm, control is by cultural and insecticidal methods. Chemical control is directed against the adult stage since larvae of the pink bollworm feed within bolls where they are not reached by pesticides. Pink bollworms have developed resistance to some organochlorine, organophosphate and carbamate insecticides formerly effective for their control. Regionally specific organophosphate, carbamate and pyrethroid insecticides are used against this pest. Control with some of these compounds is improved when chlordimeform is included for control of the bollworm complex.

Spider Mites

Several species of tetranychid mites (spider mites) are pests of cotton across the cotton belt. These pests are of greatest importance in the arid west (San Joaquin Valley of California) and outbreaks elsewhere are common during periods of drought. Outbreaks are also associated with use of broad spectrum insecticides, particularly pyrethroids.

Spider mites have a wide range of native weed and crop hosts. Outbreaks are commonly associated with the presence of these hosts. Spider mites feed on leaves and vegetative tissues, debilitating the plants. Defoliation is also associated with some species where infestations are heavy.

Spider mite infestations are often suppressed by a complex of arthropod predators and in the humid Southeastern U.S. by a fungal disease. They are controlled with insecticides that are specifically selective against the pest group. They may be suppressed temporarily with several organophosphate compounds. Chlordimeform, when used in a bollworm control program, is useful in suppressing the spread of spider mite infestations. It is not, however, effective for control of established infestations at rates that are used for bollworm control.

[illegible] bollworm [illegible] Chemical control is directed against [illegible] larvae of the pink bollworm [illegible] not reached by pesticides. Pink bollworm [illegible] insecticides [illegible] for control of the bollworm [illegible]

Mites

Several species of tetranychid mites (spider mites) [illegible] occur across the cotton belt [illegible] potential importance in the [illegible] and [illegible] particularly [illegible]

Spider mites have a wide range of [illegible] are commonly [illegible] Spider mites [illegible] leaves and [illegible] some species where infestations are heavy.

Spider mite [illegible] southeast [illegible]

INSECT PESTS OF SPORADIC ECONOMIC IMPORTANCE

Cabbage looper	_Trichoplusia ni_
Cotton aphid	_Aphis gossypii_
Cotton leafperforator	_Bucculatrix thurberiella_
Cotton leafworm	_Alabama argillacea_
Darkling ground beetles	_Alabama argillacea_
Garden webworm	_Achyra rantalis_
Soybean looper	_Pseudoplusia includens_
Saltmarsh caterpillar	_Estigmene acrea_
Whitefringed beetle	_Graphognathus peregrinus_
Whitefringed beetle	_Graphognathus leucoloma_
Yellowstriped armyworm	_Spodoptera ornithogalli_
Western yellowstripped armyworm	_Spodoptera praefica_
Cutworms	
Black cutworm	_Argotis ipsilon_
Palesided cutworm	_Agrotis malefida_
Variegated cutworm	_Peridroma saucia_
Granulate cutworm	_Feltia subterranea_
Army cutworm	_Euxoa auxiliaris_
Grasshoppers	
American grasshopper	_Schistocerca americana_
Differential grasshopper	_Melanoplus differentialis_
Lubber grasshopper	_Brachystola magna_
Migratory grasshopper	_Melanoplus sanguinipes_
Redlegged grasshopper	_Melanoplus femurrubrum_
Twostriped grasshopper	_Melanoplus bivittatus_
---	_Trimerotropis pallidipennis_
Plant bugs	
Clouded plant bug	_Neurocolpus nubilus_
Ragweed plant bug	_Chlamydatus associatus_
Rapid plant bug	_Adelphocoris rapidus_
Superb plant bug	_Adelphocoris superbus_
---	_Creontiades debilis_
---	_Reuteroscopus ornatus_
---	_Reuteroscopus sulphureus_
---	_Paraxentus guttulatus_
---	_Credontidaes rubrinervis_
Spider mites	
Carmine spider mite	_Tetranychus cinnabarinus_
Desert spider mite	_Tetranychus desertorum_
Fourspotted spider mite	_Tetranychus canadensis_
Pacific spider mite	_Tetranychus pacificus_
Schoene spider mite	_Tetranychus schoenei_
Strawberry spider mite	_Tetranychus turkestani_
Timid spider mite	_Tetranychus tumidus_
Twospotted spider mite	_Tetranychus urticae_
---	_Tetranychus ludeni_
---	_Tetranychus yustis_
Arctiid caterpillars	
---	_Diacrisia virginica_
---	_Callarctia phyllira_
---	_Callarctia arge_

---	*Callarctia oithona*
Stink bugs	
Brown stink bug	*Euschistus servus*
Conchuela stink bug	*Cholorochroa ligata*
Dusky stink bug	*Euschistus tristigmus*
---	*Euschistus conspersus*
Green stink bug	*Acrosternum hilare*
Onespot stink bug	*Euschistus variolarius*
Redshouldered plant bug	*Thyanta custator*
Say stink bug	*Chlorochroa sayi*
Southern green stink bug	*Nezara viridula*
Western brown stink bug	*Euschistus impictiventris*
---	*Thyanta rugulosa*
---	*Thyanta pallidovirens*
Thrips	
Flower thrips	*Frankliniella tritici*
---	*Frankliniella exigua*
---	*Frankliniella gossypiana*
Western flower thrips	*Frankliniella occidentalis*
Onion thrips	*Thrips tabaci*
Soybean thrips	*Sericothrips variabilis*
Tobacco thrips	*Frankliniella fusca*
---	*Kurtomathrips morrilli*
Bean thrips	*Calothrips fasciatus*
---	*Calothrips phaseoli*
---	*Scirtothrips* spp.
White flies	
Bandedwing whitefly	*Trialeurodes abutilonea*
Greenhouse whitefly	*trialeurodes vaporariorum*
Sweetpotato whitefly	*Bemisia tabaci*
Wireworms	
Sand wireworm	*Horistonotus uhlerii*
---	*Melanotus* spp.
Pacific coast wireworm	*Limonius canus*
Tobacco wireworm	*Conoderus vespertinus*

There are over 60 additional species of insects that are listed in the 37th Annual Conference Report on Cotton-Insect Research and Control (USDA 1984). Those additional insects have been observed causing damage to cotton; however, their damage is not considered to be of serious economic importance and their occurrence is considered to be very sporadic in nature.

APPENDIX B

1986 Chlordimeform Use Conditions. California Department of Food and Agriculture. Mimeograph, 7 pages.

June 16, 1986

1986 CHLORDIMEFORM USE CONDITIONS

I. GENERAL REQUIREMENTS

A. Chlordimeform shall be used only in Imperial, Riverside, and San Bernardino Counties.

B. Use permits for chlordimeform shall be issued only to growers participating in the Imperial Valley Cotton Pest Abatement District (CPAD) or the Desert Cotton Growers Association.

C. All chlordimeform applications shall be made by licensed pest control operators only. Method of application shall be aircraft only.

D. Chlordimeform shall not be applied prior to June 16, 1986.

E. After June 16, 1986 the application of azodrin, methyl parathion, or parathion will be allowed only to a site not treated with chlordimeform. However, the application of azodrin, methyl parathion, or parathion to a site treated with chlordimeform shall be grounds for cancellation of the chlordimeform permit for that site.

F. The application of azodrin, methyl parathion, and parathion to a site after July 1, 1986, shall be grounds for refusal or cancellation of a chlordimeform use permit for that site.

G. Paragraphs E and F shall not apply if such applications are approved by the Commissioner or Director as part of the Boll Weevil Eradication Program.

H. Chlordimeform shall not be tank mixed with more than two other pesticides except for spray adjuvants.

I. Chlordimeform shall only be used for the target pest: tobacco budworm, cotton bollworm, *Heliothis* spp.

J. A maximum of eight applications of chlordimeform may be made to each site. The recommendation for the application of chlordimeform shall be submitted along with the Notice of Intent. The Notice of Intent or recommendation shall contain the prior number of applications made to that site, and verification of the presence of the target pest.

K. Dilution Rate: chlordimeform shall not be used in less than three gallons of water per acre. Dilute with water only.

L. Preharvest interval shall be 30 days.

M. All application personnel shall attend the chlordimeform training program approved by the county agricultural commissioner prior to working with chlordimeform.

N. The commissioner may require that mix/load and application operations not commence until a representative of the commissioner is on site to monitor such operations. The commissioner shall notify the pest control operator, within 12 hours of receipt of the notice of intent, which applications are to be monitored.

II. APPLICATION EQUIPMENT REQUIREMENTS

A. The following aircraft equipment specifications shall be used:

1. A setup which results in 70 percent deposition or greater and droplet size greater than 200 microns (volume median diameter). Prior to using chlordimeform, the pest control operator shall submit to the commissioner copies of aircraft deposition tests verifying such deposition and specifying equipment setup, including: nozzle type, size, placement and orientation; boom pressure and configuration; and speed and height at which test was performed. Applications shall take place only under the equipment setup which achieved optimum deposition; or

2. A setup which has been advised by the University of California and approved by the Director as equivalent to II-A-1 or II-A-3; or

3. A setup which has the following aircraft equipment specifications:

a. Boom pressure not exceeding 40 pounds per square inch.

b. Fixed wing aircraft and helicopters equipped with jet nozzle having an orifice of not less than 1/16 inch in diameter, orifices directed backward, parallel to the horizontal axis of the aircraft in flight. A Number 45 (or equivalent) or larger whirlplate may be used.

c. There shall be at least three feet between each wing tip (or rotor tip) and the working boom.

B. Application equipment such as aircraft, mix/load trucks and trailers, and vehicles used for flagging which has been contaminated with chlordimeform shall be thoroughly cleaned with nutrasol or similar product

and flushed with clean water prior to use for other purposes.

III. PROTECTIVE CLOTHING AND EQUIPMENT REQUIREMENTS

A. Before a use permit is issued to the permit applicant, the pest control operator(s) named on the application shall have on hand, one week's supply of protective clothing and equipment, as required by restricted material permit conditions.

B. Persons mixing/loading chlordimeform shall wear the following:

1. One-piece, long-sleeve cloth coveralls;

2. Washable cloth cap (tight weave) or hard hat;

3. Waterproof boots (rubber or neoprene);

4. Waterproof gloves (rubber or neoprene);

5. A full-face shield; and

6. A waterproof apron when mixing chlordimeform packaged in water soluble bags.

C. Pilots shall wear the following:

1. One-piece, long-sleeve cloth coveralls;

2. Cloth gloves (washable);

3. Work boots (appropriate for flying);

4. Waterproof gloves and boots (rubber or neoprene), and full-face shield while cleaning or adjusting nozzles; and

5. Waterproof gloves (rubber or neoprene) while cleaning windshield.

D. Flaggers

1. The following flagging methods are acceptable:

   a. Use of an electronic guidance system or other system that does not use human flaggers; or

   b. Flagging from a closed vehicle.

      (1) The person in the vehicle shall not open the windows during application; and

      (2) She/he shall wear clean, one-piece, long-sleeve cloth coveralls daily.

c. A human flagger may be used without a vehicle if they wear:

(1) One-piece, long-sleeve cloth coveralls;

(2) Washable cloth cap (tight weave);

(3) Heavy-duty work boots, waterproofed; and

(4) Cloth gloves.

d. On each pass over the treatment area, chlordimeform shall not be discharged within 100 feet of a flagger.

The buffer zone shall be treated only after the flagger is completely and safely away from the field.

E. Persons involved in the cleaning operation in the mix/load area; cleaning aircraft, vehicles, etc.; cleaning the flight pad; or spill clean-up shall wear the following:

1. Waterproof rainsuit or full-body apron and head covering;

2. Face shield or full-face respirator;

3. Waterproof gloves (rubber or neoprene); and

4. Waterproof boots (rubber or neoprene).

F. Persons involved in adjustment or repair work on equipment contaminated with chlordimeform during the application process shall wear the following:

1. One-piece, long-sleeve cloth coveralls;

2. Washable cloth hat or hard hat;

3. Waterproof boots (rubber or neoprene);

4. Waterproof gloves (rubber or neoprene); and

5. Full-face shield.

G. Mechanics shall perform maintenance on aircraft or other equipment only after contaminated equipment is cleaned with nutrasol or similar product and rinsed with clean water, or if equipment cannot be decontaminated the following shall be worn:

1. One-piece, long-sleeve cloth overalls; and

2. Disposable waterproof gloves or cloth gloves.

H. All protective equipment such as waterproof gloves and boots shall be washed each time before they are removed.

I. Waterproof gloves (rubber or neoprene) shall be made usable (by cutting in half) at end of each work day or when inside of gloves become contaminated, whichever occurs first.

J. Used protective clothing shall be stored in an impervious container until laundered.

K. Used protective clothing shall be laundered daily by the employer. The person or firm designated to launder used protective clothing shall be informed that clothing has been exposed to chlordimeform and that waterproof gloves shall be worn when handling clothing.

L. One complete, clean, change of protective clothing (coveralls, gloves, hat, and boots) shall be available at the work site in case of contamination.

M. Any person entering a chlordimeform treated field within 24 hours of application shall wear the following:

1. Waterproof rainsuit;

2. Waterproof boots (rubber or neoprene); and

3. Waterproof gloves (rubber or neoprene).

IV. MIXING/LOADING REQUIREMENTS

A. Only closed systems meeting CDFA closed system criteria shall be used for mixing and loading liquid formulations of chlordimeform.

B. Service containers used for transport or storage shall be equipped with dry-break couplers or reverse action pump, or a similar system.

C. When using chlordimeform packaged in water soluble bags, the following procedure shall be used:

1. Add 3/4 of the required amount of water to the mix tank;

2. Add desired amount of "dry" pesticides and materials to mix tank with agitator running;

3. Add required amount of soluble bags into mix tank with agitator running. For mix tanks that introduce water at the upper portion of the mix tank (above water line source), water source shall be turned off before adding soluble bags into mix tank. Additionally, if impellers rotate above the water

line, the impellers shall be stopped or more water added before adding soluble bags;

4. Close lid of mix tank. The lid shall not be opened after chlordimeform has been added;

5. Add all "liquid" pesticides to mix tank through closed system with agitator running;

6. Add the remainder of water.

V. MEDICAL MONITORING PROGRAM REQUIREMENTS

A. Employees are required to have medical supervision by a physician. Medical supervision shall include:

1. Routine urinalysis and urine cytology within 30 days prior to onset of exposure (baseline); and

2. Follow-up urinalysis and cytology each 30 days after the baseline if the employee worked with chlordimeform during that period.

3. A final urinalysis and cytology within 12 days after the employee has completed work with chlordimeform.

B. Within five days after the end of each month, employers shall submit to the commissioner a certification verifying that baseline or follow-up urine testing has been completed for each employee. Employers shall account for each employee not tested (e.g., did not work with chlordimeform, no longer employed, etc.).

C. Employers shall maintain copies of a physician's certification verifying that baseline and follow-up urine testing has been completed for each employee for one year and shall make them available, on request, to the commissioner.

D. Employers shall follow the recommendations of the medical supervisor.

E. Employer shall notify the commissioner if and when the physician providing medical supervision recommends removal of any person from chlordimeform exposure.

VI. FIELD ENFORCEMENT URINE METABOLITE MONITORING REQUIREMENTS

A. In addition to urine samples required under the medical monitoring program in V, the employer shall have employee(s) submit urine samples, at the discretion of the commissioner, for urine metabolite monitoring.

B. Employee(s) with metabolite levels of more than 0.5 ppm for two consecutive samples shall be required to attend a training session before returning to work with chlordimeform. If two or more employees have metabolite

levels of more than 0.5 ppm for two consecutive samples, the authorized agent shall also be required to attend a training session.

C. If the majority of a pest control operator's exposed employees exhibit chlordimeform metabolite levels in excess of 800 ppb in two consecutive analyses, all chlordimeform permits designating said firm as pest control operator shall be revoked. Reinstatement of the permits shall be at the discretion of the agricultural commissioner after:

1. Corrective actions to reduce chlordimeform exposure have been taken; or

2. A new pest control operator is designated on the permit.

VII. APPLICATION REQUIREMENTS

A. Chlordimeform shall not be discharged more than 10 feet above the crop.

B. No application shall commence or be allowed to continue when wind velocity at treatment site exceeds 10 miles per hour.

VIII. BUFFER ZONES

A. No chlordimeform shall be discharged within 100 feet of a canal or water source designated by the commissioner as being a domestic water source.

B. No chlordimeform shall be discharged within 100 feet of food crops.

C. No chlordimeform shall be discharged by fixed wing aircraft within 1/4 mile of any area zoned as residential where people are actually residing, or other inhabited residential areas designated by the commissioner, or any school in session or due to be in session within 24 hours.

D. No chlordimeform shall be applied within 100 feet of an inhabited dwelling.

E. No chlordimeform shall be discharged within 300 feet of field workers.

APPENDIX C

Surveillance Standards for 1986 Chlordimeform Program, California Dept. of Agriculture. Sacramento, CA. Mimeograph. 3 pages. 1986.

SURVEILLANCE STANDARDS FOR 1986 CHLORDIMEFORM PROGRAM

I. GENERAL

Immediately following any modification of permit conditions, counties will contact PCOs, PCAs, and growers to ensure distribution and understanding of changes.

II. MEDICAL MONITORING REVIEW

Employers are required, within five days after the end of each month, to submit to the commissioner a certification verifying baseline or follow-up urine testing has been completed for each employee.

A. Counties will verify on the sixth day of each month that each PCO has accounted for all employees. This will be accomplished by reviewing the Medical Monitoring form submitted by the PCO.

B. If the PCO(s) does not submit the Medical Monitoring form as required, counties will automatically issue a Cease and Desist Order to the PCO, suspending his ability to apply chlordimeform until the PCO complies with the Medical Monitoring requirements.

III. METABOLITE SAMPLING

A. Scheduled sampling - Counties will require submission of metabolite samples from each PCO at least two times during the first six weeks of the PCO's application schedule. Metabolite sampling should be scheduled so as not to overlap with weeks in which NOI inspections will be performed.

B. Counties may require metabolite samples of all crew members if noncompliances are found during inspections.

C. The county will require any individual with a metabolite level over 0.5 ppm to continue to submit samples until the level decreases to under 0.5 ppm.

D. When any individual has metabolite over 0.5 ppm, the county will conduct an in-depth workplace evaluation to determine the cause of excessive exposure.

E. Counties will require individuals with levels over 0.5 ppm for two consecutive samples to be retrained before returning to work. The county will require the authorized agent for the PCO to attend a training session if two or more

employees have levels over 0.5 ppm for any two consecutive samples.

F. Counties will notify PCOs when any individual has metabolite levels over 0.8 ppm and advise of consequences of paragraph 111-G.

G. When more than 50 percent of the individuals in an operation have over 0.8 ppm levels in any two consecutive samples, the county will revoke all permits for which the firm is designated.

IV. INSPECTIONS

A. Mix/Load and Application

1. The county will perform sufficient inspections, using NOI condition as necessary, to total by the end of the season, the equivalent of three PCOs per week in Riverside and four PCOs per week in Imperial. The number of inspections per PCO will be proportionate to the amount of chlordimeform applications which that PCO makes; however, at least one mix/load and one application inspection will be performed on each PCO.

2. If noncompliances are found, counties will perform an announced inspection (using NOI condition) on that PCO on the next night he applies chlordimeform.

3. Inspections must include an evaluation of conditions concerning application equipment, protective clothing and equipment, mixing and loading, application, and buffer zone requirements. For each inspection form completed, include names, work activities of all employees, and aircraft N number involved in the application.

B. Equipment and Employer Headquarter

1. The counties will perform at least one equipment and employer headquarter inspection prior to the first application by the PCO, to evaluate:

a. If proper and sufficient safety equipment and impervious container is available. If not, a reinspection will be required prior to the PCO being allowed to apply chlordimeform.

b. If PCO's aircraft to be used for chlordimeform applications comply with aircraft equipment specifications. If not, a reinspection will be required prior to the PCO being allowed to apply chlordimeform.

2. Counties will verify medical monitoring records submitted by the physician to the PCO.

C. Preapplication Site Inspections

The counties will perform preapplication site inspections as early as possible during the season. The inspection will include verifying that the target pest is present in the field to be treated.

D. NOI and Use Report Record Review

1. The counties will review all NOIs and use reports to verify compliance with the prohibition against azodrin, methyl parathion and parathion, and with mixing limitations; or, upon receipt of an NOI for chlordimeform, counties will cancel the specified site from any permit for azodrin, methyl parathion, or parathion.

2. The counties will review all NOIs and recommendations to ensure that the prior number of applications made to that site are noted and will verify that number for at least 20 percent of the recommendations submitted.

APPENDIX D

Explanation of Economic Evaluation

These return changes do not account for farm program payments and, hence, are computed for nonparticipants. For program participants not using the pesticide(s) in question, returns per acre will not change as long as market price does not exceed target price or actual yield is less than farm program payment yield. Program participants who use the pesticide(s) will lose collateral for nonrecourse loans, but their deficiency payments will remain unchanged. Their per acre returns will decrease by yield loss, multiplied by the nonrecourse loan rate or market price, whichever is greater, plus the change in control costs.